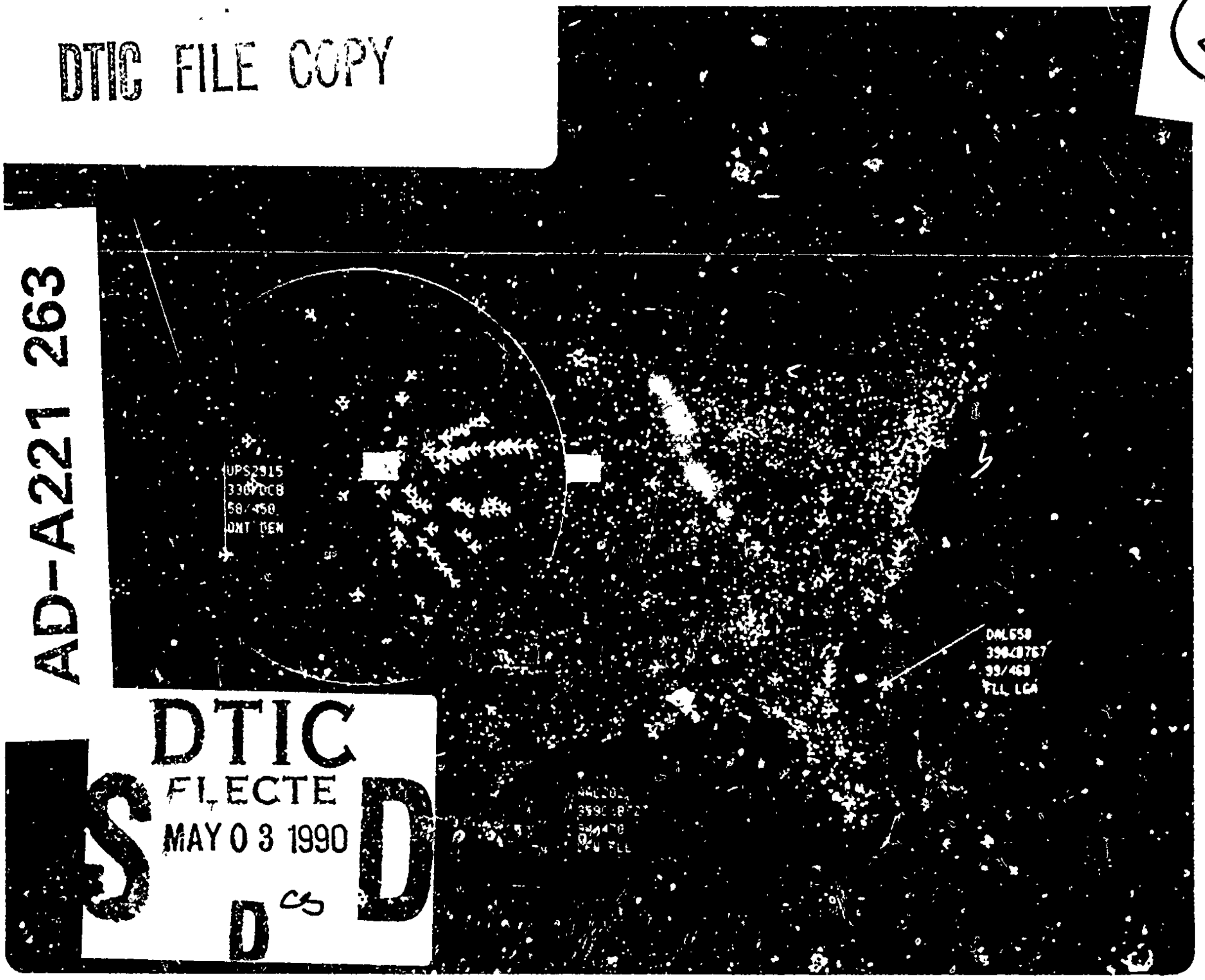

The Federal Aviation Administration Plan for Research, Engineering, and Development

Volume I: Program Plan

January 1989

Cover Photograph: Aircraft Situation Display

The aircraft situation display (ASD) -- currently operational at central flow control in Washington, D.C., and at traffic management units in Los Angeles, Chicago, and New York -- is one product of the FAA's advanced traffic management system project (Project 3.1).

Shown here is the ASD's real-time view of all the nation's air traffic at 9 a.m. (EST) one morning in August 1988. Aircraft inbound to Denver are highlighted in color; a 500-mile ring around the airport is shown. Also depicted are details for three flights, one from United Parcel Service (UPS2915), another from American Airlines (AAL282), and a third from Delta Air Lines (DAL658); aircraft type (Boeing 767 for DAL658); minutes to destination (98 minutes for DAL658); ground speed (468 knots for DAL658); and origin to destination (FLL, or Fort Lauderdale, to LGA, LaGuardia, for DAL658).

The ASD, which has many other features beyond those summarized here, was developed through use of a rapid prototyping approach.

US Department of Transportation
Federal Aviation Administration

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The publication of this Research, Engineering and Development (R,E&D) Plan represents a new start in the revitalization of the Federal Aviation Administration's (FAA) R,E&D Program. We have taken the initial steps to develop a program to work more closely with the aviation industry and to be responsive to the Aviation Safety Research Act of 1988. The plan also provides a balance between near- and long-term research activities to provide effective solutions to immediate problems and provide a base for the aviation system of the 21st century.

The recent R,E&D Conference was also a step in opening communications between the FAA and the aviation community. I was encouraged by the support shown at the conference and feel confident that we can continue the dialogue and partnership toward a greater consensus on the needs and priorities of the FAA's research program. We will soon have in place an R,E&D Advisory Committee to represent the aviation interests of the country and work with us in further defining the program to be undertaken by the FAA.

The plan introduces the idea of major mission areas which will provide us a means of "top down" systems engineering planning of our research activities. It is also responsive to my Impact 88 Program which is the FAA's pledge to accelerate agency efforts to safely steer civil aviation through "turbulent skies."

I am enthusiastic about this plan. It is admittedly only a start, but a very important one. I believe that the R,E&D efforts are our lifeline to the future and a necessary requirement for an improved position for the United States in the world market place. We look forward to working with you during the coming year to further improve the plan and the spirit of cooperation that it has engendered.

T. Allan McArtor
Administrator

U.S. Department
of Transportation

Federal Aviation
Administration

The Federal Aviation Administration Plan for Research, Engineering, and Development

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1. Executive Summary

The Federal Aviation Administration (FAA) has embarked on a major effort to revitalize its Research, Engineering, and Development (RE&D) program. It is committed to providing a renewed focus and direction for RE&D, with the following objectives:

- Enhance the capability of the FAA and aviation community to meet future challenges.
- Strengthen partnerships with international organizations, other government agencies, industry, and academia to better understand and respond to future needs and opportunities.
- Provide for full compliance with legislative direction, including the Aviation Safety Research Act of 1988.
- Establish a careful balance between support for the National Airspace System (NAS) Facilities and Equipment (F&E) Plan, Impact 88 objectives, and the agency's other high-priority programs.
- Meet the short-term needs of the air transportation system as well as plan for tomorrow.

While significant progress has been made over the past year, there is still much to be done. Because RE&D is the FAA's lifeline to the future, the agency must continue its journey to build a strong base for its missions in aviation capacity, safety, security, and efficiency and to meet the operational requirements of the aviation community. A revitalized and refocused RE&D program is as necessary to meet the demands of the future as was the RE&D of the 1960s and 1970s to the development of the NAS F&E Plan.

The establishment of the new System Development (AXD) and Advanced Design and Management Control (ADM) organizations has helped to focus attention on RE&D within the agency. The new ADM organization has an operations research capability that will be used to identify potential or existing system problems and then to evaluate developmental solutions to these problems. This capability will grow and become an integral part of the FAA's RE&D planning and investment analysis functions, in addition to supporting current operational needs. ADM has oversight responsibilities over both the NAS F&E and RE&D programs, providing a tight coupling between RE&D activities and major development initiatives. This oversight will also provide inputs, along with those of the industry, to the process of setting priorities for RE&D and F&E budget formulation.

ADM is the focal point for the definition and justification of the RE&D program; it has complete responsibility for all activities, regardless of the organizational unit performing the work. To that end, the FAA has initiated a process for taking a top-down systems look at the agency's missions and evaluating how effectively RE&D programs are meeting mission objectives.

This year, the FAA has developed the concept of major missions areas as a means for better correlating its RE&D projects to the primary missions of capacity, safety, security, and efficiency. Current and planned RE&D projects will be assessed as to their contribution to the accomplishment of these missions. Such assessments will be used by the FAA to evaluate how resources should be allocated in the context of total aviation system needs.

A critical feature of the RE&D planning process is the early identification of issues and technological opportunities through continuing dialogue with the aviation community and use of all available technical resources, both inside and outside the agency. During the past year, existing agreements have been expanded and new programs put in place for cooperative or joint efforts with the Department of Defense (DoD), National Aeronautics and Space Administration, National Weather Service, Transportation Safety Board, the aviation industry, nonprofit organizations, universities, state and local planners, and foreign governments.

There are many forces at work that dictate an evolving aviation system. The continuing ability of the aviation community to ensure the capacity, safety, security, and efficiency of air commerce is being challenged as the result of rapidly changing economic and technical forces. The increasing demand for commercial aviation will place additional pressures on our airports, creating the need for better tools for future planning and new capabilities to enhance current capacity. Advanced technologies, including propulsion systems, avionics systems, and structures and materials, in combination with new types of aircraft, will, in many cases, require new certification procedures and a supporting infrastructure. Heightened awareness of the importance of human performance in aviation safety has raised questions concerning the training and certification of aircrews and air traffic controllers and the ability to safely and effectively integrate new technologies into the system. The boom in air travel, along with intense industry competition, has resulted in increased aircraft utilization and growing concerns about an aging aircraft fleet. The need to provide passengers with a high level of security against terrorists calls for continued emphasis on the development of new systems for explosives and weapons detection and the enhancement of overall security. Finally, expansion and improvements must be accomplished in a manner that ensures the safest utilization of the airways.

In response to these forces, the FAA is addressing several special emphasis areas within the context of its total RE&D program.

In cooperation with the Industry Task Force on Airport Capacity, the agency is working to optimize its investment in this area and address 13 identified objectives. High priority has been placed on completing the parallel and converging runway programs. The level of funding is being increased on terminal air traffic control automation activities, including the descent advisor, terminal sequencing aid, and final-spacing aid. In fiscal year 1989, work is being initiated on pilot use of cockpit traffic displays based on information available from the onboard traffic alert and collision avoidance system. Airspace and airport modeling activities are being increased. These programs will be used to support airport task force activities and will also serve as a basis for evaluating proposed RE&D and capital investments. Emphasis continues to be placed on improved pavement development, lighting, marking, and runway exit location definition. A plan is also in place to start an increased effort toward the development of an airport surface traffic automation system.

In the area of human performance, the FAA has committed to a stronger focus on examining how people function in their jobs. The increasingly complex aviation system is placing new and different demands on system operators. Research will focus on flight crew performance (in conjunction with the Air Transport Association), air traffic controller performance, and increased aeromedical research. Efforts will be directed toward an increased awareness of the psychological factors associated with accidents and the actions taken by the FAA to correct these areas. Research will also focus on how best to introduce and utilize new technologies and capabilities. The role of the Civil Aeromedical Institute will be expanded.

In response to issues highlighted by the Aloha Airlines incident and in concert with the joint FAA/industry conference held last June, the FAA has increased RE&D activities addressing safety issues associated with aging aircraft. This year's RE&D Plan focuses on structural integrity, failure mechanisms, nondestructive inspection techniques, training, and human performance research.

Combining the advantages of both rotorcraft and fixed-wing aircraft, the tiltrotor is a new technology on the civil aviation horizon, possessing the potential to solve some of our present airport capacity problems. In June 1988, the FAA administrator announced a five-point program for the introduction of a civil tiltrotor into the national aviation system. RE&D is aimed at acquiring the technical knowledge needed for tiltrotor certification and for the development of an infrastructure to support and take advantage of this aircraft's unique operating characteristics.

The FAA continues to seek better ways to allow planes to land in all types of weather conditions. A new RE&D initiative under way, called "synthetic vision," applies millimeter-wave technology to provide pilots with a visual image for use in low-visibility environments. This program, a joint FAA/DoD/industry initiative, will develop a "head-up" display for the pilot's windshield field of view.

The FAA has sharpened its focus on the use of satellite technology, through efforts addressing civil aviation applications of the global positioning system and the early introduction of automatic dependent surveillance in oceanic airspace.

These are some of the key topics covered in the RE&D Plan. Each one highlights an Impact 88 initiative or some other current issue receiving special emphasis within the FAA. Several actions have been undertaken, but they are only the beginning of the journey aimed at revitalizing the RE&D program. The FAA must work together with the aviation industry to build an RE&D program that best meets the needs of the community, to identify additional requirements and programs that will enable it to better accomplish its missions, and to jointly support the RE&D program.

The new RE&D emphasis, the maturing of the NAS F&E Plan, and new issues in the air commerce system have influenced resource allocation within the FAA's RE&D program. This changing resource picture also responds to conclusions reached in a number of studies of the aviation system, such as those from the Industry Task Force on Airport Capacity, the Air Transport Association, the Future Air Navigation Systems Committee, and the Office of Technology Assessment. Many of the recommendations in these studies are reflected in this plan and have resulted in changes to FAA resource allocations, as shown in Figure 1-1. Completed projects that supported the NAS F&E Plan in the efficiency mission are beginning to be supplanted by safety and capacity initiatives.

The current RE&D Plan is an initial step in the right direction. The FAA is actively soliciting inputs from the aviation community on where and how the RE&D program should be focused. The agency encourages the participation of the aviation community in the shaping and planning of its RE&D Plan. Reviews of the document and comments from the industry, an annual RE&D planning conference, and the establishment of an RE&D Advisory Committee will ensure that the plan and its implementation best serve the needs of the aviation community.

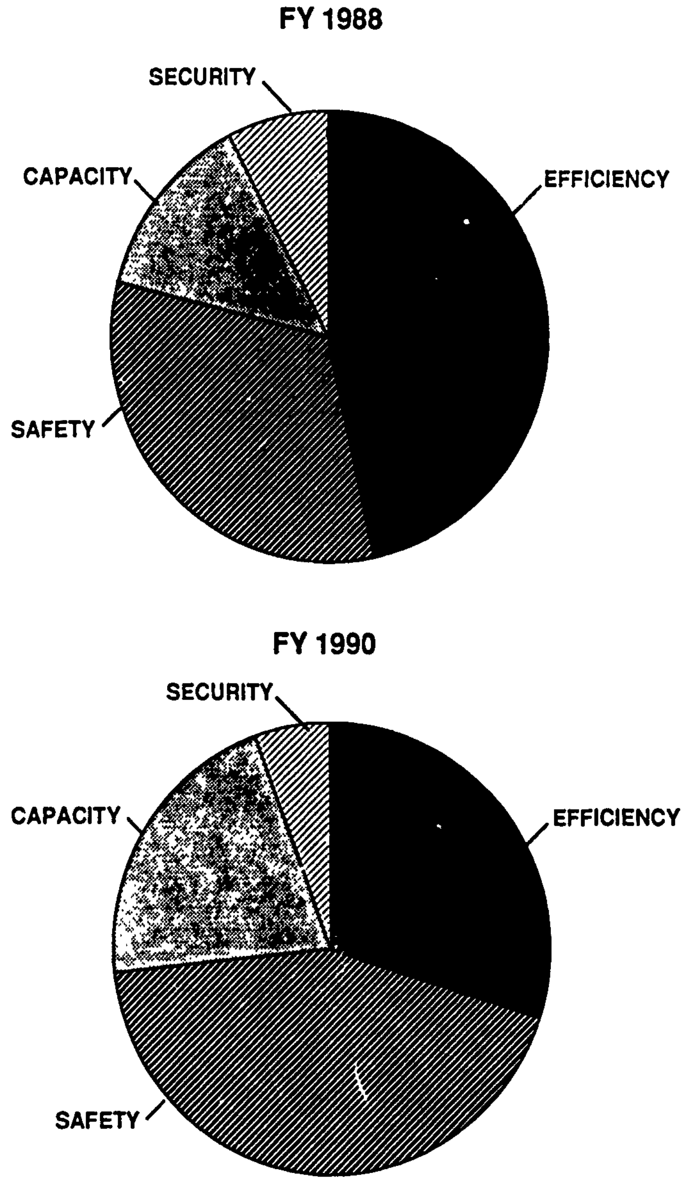


FIGURE 1-1 -- DISTRIBUTION OF RE&D RESOURCES

2. Introduction

2.1 The Research, Engineering, and Development Plan -- Purpose and Scope

The FAA's RE&D program is a major force for improving air traffic control (ATC) operations and aviation safety and security in the United States. The current RE&D Plan represents one of the steps taken by the FAA to provide a new emphasis and direction for its research and development program. This program aims at a careful balance between near- and long-term efforts, incorporating technological initiatives involving greater use of both modeling and operations research; a focus on human performance in aviation; cooperative efforts with the aviation community; and the use of all available technical resources, both inside and outside the agency.

Recent accomplishments resulting from the FAA's ongoing RE&D programs include:

- Aircraft situation displays -- Provide controllers with real-time traffic flow management capabilities.
- Terminal Doppler weather radar (TDWR) system -- Detects microbursts and abrupt wind shifts near airports, enhancing safety during takeoffs and landings.
- Airborne traffic alert and collision avoidance system (TCAS) -- Warns pilots of approaching aircraft independently of ground-based systems.
- National airspace system performance analysis capability -- Provides quantitative analysis of the impact of airline schedules, new airports, and airport modifications on air system performance.

This chapter presents the organization, planning process, and direction for the FAA's new RE&D program and summarizes the cooperative efforts being undertaken with the aviation community. Chapter 3 discusses the national aviation system; the role of the FAA in managing that system; and the social, economic, and technological drivers impacting system evolution. Chapter 4 describes the new RE&D program and provides an overview of the FAA's approach to meeting the challenges of the 21st century. Sources used in the development of this program are listed in Appendix C. Volume II presents descriptions of each RE&D project.

2.1.1 The New Emphasis for Research and Development in the FAA

The Airline Deregulation Act of 1978 and the nation's recent economic growth have produced profound changes in the national aviation system. Prior to deregulation, although subject to periods of growth, the airline industry was relatively stable. In the past decade, however, rapid growth has placed additional strains on already busy airports and on the ability of the FAA to deal with the numbers of new carriers and aircraft seeking to use the aviation system. New approaches are needed to meet growing demands and to react more quickly to system change.

A restructured RE&D planning process and program is part of the FAA's response to this challenge. Major action has been taken to consolidate diverse RE&D activities. The agency has renewed and expanded cooperative efforts with the aviation community and actively encourages their participation in the RE&D planning process. Through partnership with private industry and other government agencies, the FAA plans to make better use of all available RE&D resources both to meet current challenges and build the aviation system of the future. In addition, to reduce the time needed to implement a successful RE&D project, the FAA plans to involve users and operators in the early stages of research activities.

Along with this shift in direction has come the adoption of a "major mission area" framework for RE&D planning. With the maturing of the National Airspace System (NAS) Facilities and Equipment (F&E) Plan, RE&D is being refocused to balance support for that plan with future responses to anticipated needs.

The Major Mission Area Framework

Future RE&D planning, including resource allocation, will emphasize those programs which have the greatest potential for achieving FAA goals. For this purpose, a concept of goal-oriented major mission areas is being developed. These four missions - capacity, safety, security, and efficiency -- are the framework to be used to determine how well the FAA is meeting its operational, regulatory, technical-assistance, and policy-making responsibilities. The major missions are often related and may require trade-offs, such as keeping the level of safety fixed or improving it while at the same time enhancing efficiency. The four major mission areas are the principal framework for the current RE&D Plan.

RE&D and the National Airspace System Facilities and Equipment Plan

Initiated in 1981, the NAS F&E Plan is a comprehensive program designed to modernize and expand ATC services and airway facilities through the year 2000. The RE&D programs of the 1970s and 1980s provided the technical basis for many of the modernization projects implemented under the NAS F&E Plan. RE&D efforts in support of the initial NAS F&E Plan are diminishing, but the rapid rate of change in the aviation system has created a new set of challenges. Many of these focus on the FAA's responsibilities for air safety regulation and airport technical assistance, in addition to the enhancement and modernization of the facilities and equipment required for air traffic and airway services.

With this change in emphasis, the direction of the RE&D Plan is shifting. New programs are being initiated in areas including aircrew and air traffic controller selection, training, and performance; enhanced airport capacity; aircraft safety; and systems planning and operations research. These and other research and development efforts are being carried out in the context of a new RE&D organization and process.

2.2 The RE&D Planning Process

As part of the FAA's revitalization of RE&D, current and future research and development planning is being carried out with a number of new considerations. Most importantly, the allocation of resources will be geared to specific goals for each of the FAA's major missions -- capacity, safety, security, and efficiency. These goals will be responsive to both near- and long-term needs and to changing operational and regulatory requirements. They will also support the attainment of potential visions of aviation for the 21st century. The requirements of individual project elements will be quantified and tracked against these mission area goals.

In addition, the FAA will make full use of the research already being undertaken by outside agencies, such as the National Aeronautics and Space Administration (NASA) and the Department of Defense (DoD), by the aviation industry, and by universities. The FAA is forging new cooperative agreements with these valuable research centers to strengthen and expand these contacts. Extensive investigation and use will also be made of rapid prototyping and testbed technology. Such methods will enable the FAA to evaluate alternative technological and operational solutions in a realistic and timely manner while involving users and operators throughout the research process.

A critical feature of the new RE&D planning process is the early identification of issues and technological opportunities through continuing dialogue between the FAA and aviation community. Some of the issues of current concern are human performance, airworthiness of aging aircraft, weather and atmospheric hazards prediction, limited capacity of the nation's airports, and environmental issues such as air pollution and aircraft noise. Important technological opportunities which have been identified include advanced aircraft materials and engines; tiltrotor and hypersonic aircraft; and satellite-based communications, navigation, and surveillance (C/N/S). The FAA's response to these concerns and new technologies is an important element of the current RE&D Plan.

To support this planning process, the FAA has established a new organization and set of procedures for carrying out RE&D. These changes will help the agency better meet the evolving needs of the national aviation system and user community.

2.2.1 FAA Organization for Research and Development

The new FAA RE&D structure places responsibility for the planning, management, and control of RE&D programs under a single organization headed by the Executive Director for System Development. Although a few programs are conducted in other parts of the FAA, this change effectively consolidates a major portion of the agency's RE&D activities. A similar reorganization has been made at the FAA Technical Center.

Under the Executive Director for System Development, the new Associate Administrator for Advanced Design and Management Control will be responsible for development and coordination of the RE&D Plan and formulation of the FAA's annual RE&D budget, in conjunction with the FAA's budget office. The associate administrator is also responsible for continuing review, control, and oversight of the RE&D programs; coordination of RE&D planning with the NAS F&E Plan; support for operations research for airspace and airport planning; and interaction with foreign technical missions and the international aviation community. Major assistance to FAA headquarters for RE&D is also rendered by other elements within the FAA and Department of Transportation (DOT), including the FAA Technical Center, Civil Aeromedical Institute, and Transportation Systems Center.

2.2.2 Developing the RE&D Plan

A goal-oriented, top-down planning process is being institutionalized to aid in the development of the RE&D Plan. (See Figure 2-1.) This process establishes mechanisms to ensure that responsible and responsive decisions are made concerning the RE&D program and that the FAA's partners in the national aviation system are strongly involved. Key steps in the process are detailed below.

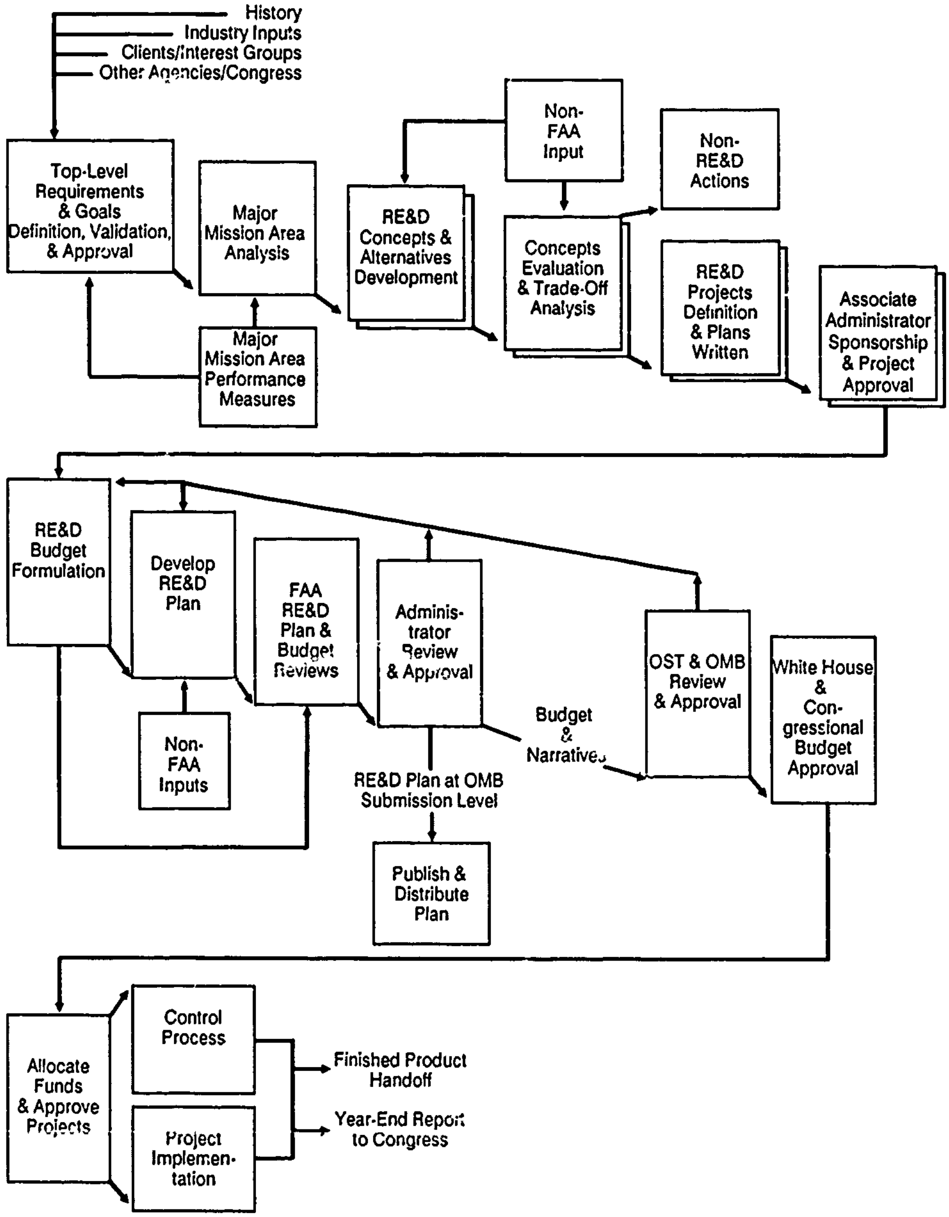


FIGURE 2-1 -- THE RE&D PLAN AND BUDGET PROCESS

Solicitation of Non-FAA Inputs

Inputs from the aviation community will be sought at several points in the RE&D process. An annual RE&D Conference will be held to review the draft RE&D Plan and receive the recommendations and views of the aviation community on future RE&D directions. (Summary proceedings of this year's conference are included in Appendix D.) In addition, aviation community inputs will be sought as the FAA refines its RE&D goals and requirements and evaluates programs within specific mission areas. The precise forum for these external recommendations has yet to be finalized. One approach may be the creation of an FAA RE&D Advisory Committee. This committee would provide the FAA administrator with advice and recommendations concerning the RE&D program and budget.

Major Mission Area Process

As indicated above, one of the cornerstones of the RE&D process is the implementation of a top-down look at the FAA's major mission areas. This year, the FAA has taken a first step toward this RE&D objective. Each of the four mission areas has been broken down into sub-missions with specific functional elements. At the same time, current and planned RE&D projects have been analyzed to determine where they fit with respect to these major missions. This analysis is being used by the FAA to evaluate how funds are being spent within the context of total FAA needs.

As the major mission area concept is developed, anticipated project results will be evaluated against quantified mission requirements. This information will be used within the FAA to better analyze current resource allocations, identify unmet requirements, and develop new concepts and alternatives for meeting these requirements. In support of the mission area process, preliminary evaluation guidelines will be developed, taking into account mission priorities, the timing to payoff of investment, the maturity of the technology, and related projects external to the FAA. A first-cut trade-off analysis will establish an initial "shopping list" of concepts and alternatives. At this point, multiple project alternatives may be carried forward to respond to a particular requirement.

Not all projected requirements will be candidates for FAA RE&D expenditures. In many cases, RE&D may be performed outside of the FAA or non-RE&D activities may meet the mission requirement.

Requirements and Goals Definition and Approval

Many factors influence the development of FAA requirements and goals. These include the FAA charter; RE&D Conference recommendations; inputs from FAA managers; other agencies' recommendations; industry, client, and international/special interest inputs; congressional, White House, DOT, and FAA management directives; aviation accidents; and historical accomplishments in each area. The FAA has embarked on a long-term program to better define the present and future requirements of the national aviation system and, where possible, to set quantified goals for meeting requirements. These goals, developed by the Associate Administrator for Advanced Design and Management Control and approved by FAA top management, will be used as a benchmark for controlling and directing the FAA's RE&D program.

RE&D Plan and Budget Cycles

The RE&D Plan and budget cycles are parallel but interrelated processes which currently take place on different annual cycles. The present RE&D Plan reflects projects within the FY 1989 approved budget, the FY 1990 presidential budget submission, and the FAA's 5-year plan for RE&D, without reference to funding levels. Because the plan takes as long as 9 months to prepare, review, approve, and publish, it does not reflect changes which may be necessary during the year to support new requirements or priorities. The RE&D budget cycle, on the other hand, is a year-long activity which includes the 5-year plan, budget narratives, the current and next fiscal-year budgets, and ongoing budgetary actions. Resources are allocated to approved projects upon the President's signing of the budget.

Project Implementation and Oversight Control

Upon receipt of an approved budget, funding is provided to the FAA program managers responsible for running the projects. In parallel with the day-to-day management of the programs, the FAA also has a separate group with responsibility for the independent review, monitoring, and evaluation of all FAA research and development.

2.3 FAA Relationships with Other Organizations

One FAA goal is to utilize nonagency research to the fullest extent possible. For this purpose, the FAA has established joint efforts with other government agencies and private organizations. These include DoD, NASA, the National Weather Service (NWS), the National Transportation Safety Board (NTSB), the aviation industry, nonprofit organizations, universities, state and local planners, quasi-governmental organizations, and foreign interests. Appendix B lists FAA projects which have DoD, NASA, and NWS participation.

2.3.1 Department of Defense

The FAA and DoD have established a number of coordinating groups to ensure consideration of defense requirements in FAA planning and operational activities. These groups are concerned with procedural, airspace, and system modernization programs. Activities in this area include:

- FAA-DoD Annual Planning Conference -- Reviews the status of all programs of mutual interest.
- National Airspace Review Advisory Committee -- Addresses a wide variety of system upgrades, with participation from 50 different government and user organizations.
- Joint Radar Planning Group -- Addresses issues and plans for modernizing the long-range radar network serving the FAA, DoD, NWS, the Customs and Immigration Service, and drug enforcement agencies, and coordinates the procurement of military radar systems.
- DoD-DOT Navigation Council -- Discusses current and future navigation issues and programs and publishes the biennial Federal Radionavigation Plan.
- Joint working group on special-use airspace -- Determines the need and requirements of special-use airspace for military operations.

In addition, several joint FAA/DoD research efforts are performed on an ongoing basis in areas such as long-range radar, the global positioning system, the next generation weather radar (NEXRAD), and the civil tiltrotor. The FAA has benefitted from a number of Defense Advanced Research Projects Agency programs, including ADA software language development, advanced and parallel computer technology, and pilot human factors research. FAA and DoD are also currently working to develop technology that will provide pilots with "synthetic vision," or high-resolution radar-like picture displays under instruments-only flight conditions.

2.3.2 The National Aeronautics and Space Administration

The FAA enjoys a close working relationship with NASA and conducts a number of joint activities and programs. FAA field offices have been established at NASA's Ames and Langley

Research Centers to coordinate joint programs, conduct RE&D activities, and explore new opportunities for cooperative research.

The FAA participates in the NASA Advisory Council and associated subcommittee activities, including the Aeronautics Advisory Committee, the Aviation Safety Reporting System Subcommittee, and the Advanced Research and Technology Subcommittee. Participation in these committees ensures close coordination of efforts and facilitates technology sharing.

Joint or coordinated FAA and NASA programs include terminal automation, terminal area flow management, windshear detection and warning systems, the human factors aspects of cockpit automation, aircraft icing prevention, aircraft crashworthiness, fire-resistant cabin materials, and advanced aircraft composite materials.

2.3.3 The National Weather Service and Other Weather Agencies

The FAA provides its requirements for weather detection and processing systems development to the NWS. Several Weather Coordination Councils have been established under the Federal Coordinator for Meteorology to oversee and direct programs designed to improve national weather systems.

The NEXRAD council, conducted under the leadership of the NWS, monitors progress on the joint FAA/DoD/NWS NEXRAD program.

The Joint Automated Weather Observation Program Council ensures coordinated development and procurement of automated weather observation systems by FAA, DoD, and NWS. The Automated Weather Information System Council assures coordination of these systems.

The National Aircraft Icing Panel, with membership from FAA, DoD, NASA, NWS, and the National Science Foundation (NSF), has developed a national plan for aircraft icing research.

Other FAA interagency agreements include those under way with the National Center for Atmospheric Research (NEXRAD, TDWR, and icing research), the National Severe Storms Lab (NEXRAD and other weather programs), and the NSF (aircraft icing).

2.3.4 The National Transportation Safety Board

The FAA works closely with NTSB toward the mutual goal of assuring a safe air transportation system. During the next decade, greater attempts will be made to utilize NTSB's databases to define RE&D projects that will enhance aviation safety before, not after, the occurrence of accidents.

2.3.5 Aviation Industry

Cooperative FAA and industry research is ongoing in a number of areas. Current joint efforts address aircrew performance, voice recognition in the automated cockpit, fuel flammability safety in post-crash fires, airframe-life prediction, and pilot vision enhancement. A National Plan to Enhance Aviation Safety through Human Factors Improvement has been developed by the Air Transport Association working with the Air Line Pilots Association, NASA, NTSB, and FAA; the plan is being used as a guide to current FAA RE&D efforts on human performance (see Section 4.3.6). The Small Business Innovation Research (SBIR) Program supplements near-term, applications-oriented programs with innovative, future-looking research and frequently offers alternative solutions or avenues of investigation. Projects currently being conducted under SBIR include the application of expert systems to air traffic controller training, an optical windshear detector, an airport-surface icing detector, and wake-vortex analysis and simulation.

2.3.6 Nonprofit Organizations

The FAA contracts for research with several nonprofit organizations such as the Lincoln Laboratory of the Massachusetts Institute of Technology (MIT) and the MITRE Corporation. The Lincoln Laboratory supports many FAA programs, including airport surveillance radar, long-range surveillance radar, NEXRAD and other weather radar equipment, TCAS, Mode S surveillance and data link, airport surface traffic control, and terminal automation. The MITRE Corporation assists with concept development, with a focus on advanced automation. Programs supported by MITRE include advanced en route ATC automation, automatic dependent surveillance (ADS) for oceanic flights, and operations research modeling to assess total national airway and airport performance.

2.3.7 Universities

The FAA often relies on the technical expertise available within many universities. One avenue for coordinated efforts is the FAA/NASA Joint University Program for Air Transportation Research, conducted at Ohio University, Princeton University, and MIT. This program is geared toward the development of a multidisciplinary approach to air transportation issues. The FAA also provides contract support for individual university RE&D projects.

2.3.8 State and Local Planners

Airport capacity is the primary emphasis of coordinated efforts with state and local planners. FAA-supported airport capacity enhancement task forces have conducted research to improve the capacity of specific airports.

Other joint efforts are also under way. Transportation authorities in the New York/New Jersey area are working with the FAA to plan future landing areas, or vertiports, in preparation for tiltrotor service. In addition, the FAA is working with Colorado state and local authorities to facilitate the construction of a new commercial airport at Denver which will replace the existing Stapleton Airport and provide greatly improved all-weather capacity. An FAA partnership has also been established with the state of Minnesota's educators in air traffic controller recruitment, aviation career education and training, airport and general aviation planning, and aviation research.

2.3.9 Quasi-Governmental Institutions

The FAA enjoys a close working relationship with quasi-governmental or joint federal/industry groups, including the Radio Technical Commission for Aeronautics (RTCA) and the Transportation Research Board (TRB).

The Radio Technical Commission for Aeronautics

The FAA has been a longstanding supporter of RTCA. This organization is recognized internationally as an authoritative forum dedicated to the resolution of technical problems concerning the application of aviation electronics and telecommunications. The major products of this relationship have been recommended technical standards and test procedures used to produce technical standard orders in the certification of avionic components and systems.

The Transportation Research Board

The purpose of the TRB, a unit of the National Research Council, is to direct and stimulate research concerning the nature and performance of transportation systems. The FAA provides funding for a TRB-sponsored biennial workshop on the future of aviation, for university research on technical and management innovations for civil aviation, and for special studies such as one, recently completed, on increasing airport network capacity.

2.3.10 Foreign Governments and International Agencies

The FAA has worked out a number of bilateral agreements with foreign countries. Specific agreements cover new system standards, composite materials, aircraft crashworthiness, satellite demonstrations, automated tracking of aircraft, collision avoidance, Mode S data link, dynamic ocean track system, aircraft icing, lightning, and fire safety research.

In addition, the FAA participates in International Civil Aviation Organization (ICAO) efforts to develop international standards for new aviation systems. ICAO recently completed a Future Air Navigation Systems (FANS) study to define the general outline of a future worldwide C/N/S system. Other joint ICAO activities include the development of standards for the microwave landing system, ADS, Mode S data link, and TCAS, and participation in the North Atlantic special planning group and the review of the general concepts of separation panel. The recommendations of ICAO-FANS and RTCA Special Committee 155, which have provided a practical blueprint for development and evaluation of future satellite-based C/N/S systems and terminal flow management, are serving as major inputs to current FAA RE&D efforts on the application of satellites to enhance aviation (see Section 4.3.4).

3. The National Aviation System

3.1 Overview -- Air Commerce and the Aviation System

Air commerce is dependent on a complex aviation system which comprises a mix of public and private organizations, including federal, state, and local governments; commercial air carriers; general aviation; aircraft manufacturers; and other support industries and services.

The vitality of the U.S. economy and our ability to compete at home and abroad are tied to the existence of a strong, growing air commerce sector. Air commerce contributes more than $200 billion annually to the economy and provides jobs to nearly a million people. In addition to its fiscal impact, air commerce makes possible the rapid movement of people and goods required for travel and tourism, retail trade, and other growing service areas, as well as for the global high-technology industries. Commercial air travel has for some years been the number one form of business intercity transportation in the country.

The national aviation system which supports air commerce encompasses airports, the aircraft fleet, and airways. Airports are managed by local governments and airport authorities. The aircraft fleet is owned and operated by air carriers, general aviation users, and the military. The FAA has responsibility for the nation's airways and air traffic control (ATC) system. In addition, all aviation activities are monitored by the FAA for conformance with safety and security guidelines.

The FAA role in the aviation system is described in Section 3.2. Section 3.3 addresses the relationship between RE&D and the National Airspace System (NAS) Facilities and Equipment (F&E) Plan and highlights some of the system improvements that are being realized through the plan's implementation. A discussion of the forces influencing the evolution of the aviation system and FAA role is contained in Section 3.4.

3.2 The FAA Role

To achieve its missions, the FAA performs four basic roles within the aviation system: operation of the air traffic and airways service system, regulation of safety and security, provision of technical assistance to airports, and formulation and coordination of national and international aviation-related policy.

3.2.1 FAA Operational Responsibilities

The FAA develops, operates, and maintains the ATC and airways service system. Primary functions are the provision of air traffic control services; communications, navigation, and surveillance services; and weather and flight services.

Air Traffic Control Services

Air traffic control consists of two principal services: aircraft separation and flow management.

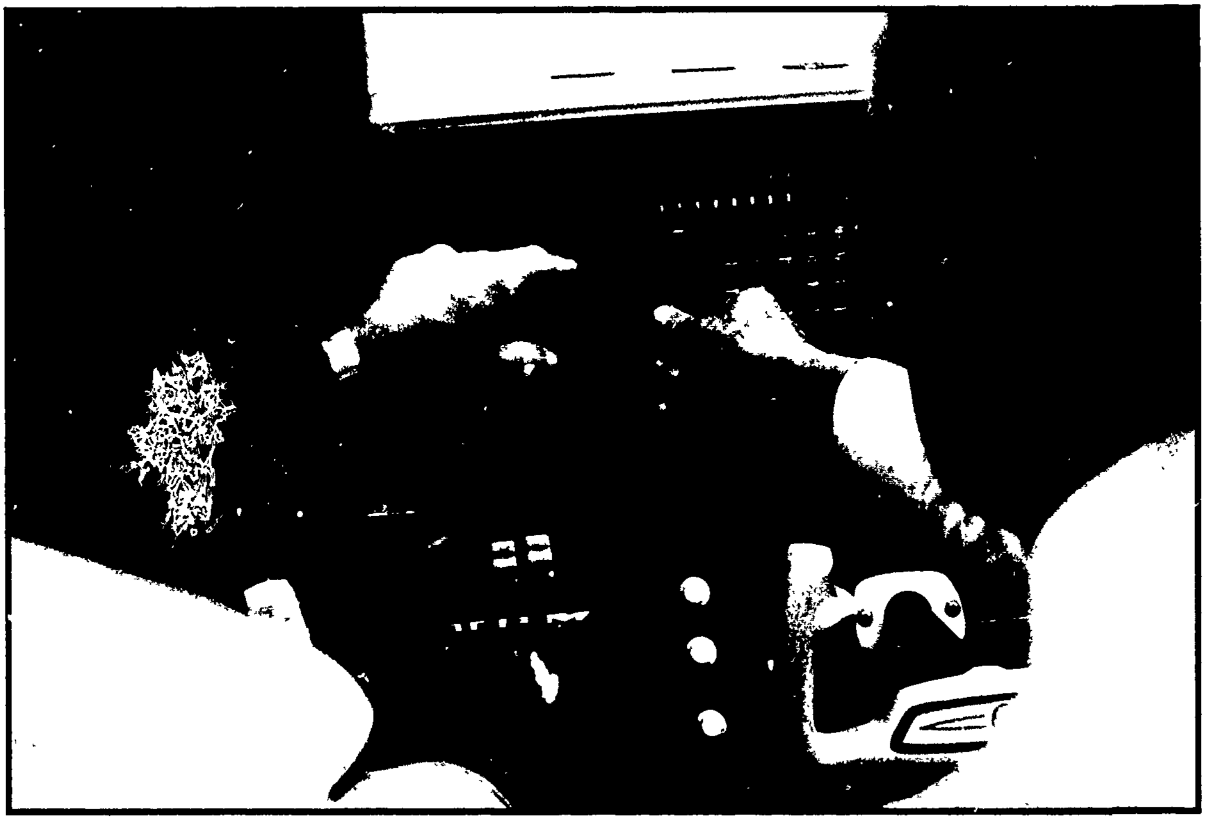
Separating aircraft in controlled airspace and alerting those flying too close to the ground are a controller's top priorities. Controllers constantly monitor flight progress to identify potential aircraft-to-aircraft and aircraft-to-terrain conflicts and routing errors in airspace. When potential conflicts are identified, speeds, routings, or altitudes are revised to ensure that the appropriate standards for separation minima are met.

Flow management balances traffic demand against capacity at an aggregate level to the extent that local air traffic control will be able to handle the remaining imbalance. Controllers use aircraft data provided by advance schedules, filed flight plans, and on-line updates of flight status; weather information, facility outages, and local conditions are supplied from sites around the country. Automated tools provide analyses showing which air traffic sectors, air route fixes, and airports are likely to be at or near capacity in the near future. Actions are taken to reduce demand at seriously impacted areas without inadvertently increasing demand at other locations. Such actions include rerouting, airborne delays, and ground holds applied to specific aircraft. Each solution is continuously monitored and then modified, as the situation changes, to make optimum use of all available capacity.

Communications, Navigation, and Surveillance Services

Communications services are used by the pilot to obtain flight clearances; to report flight progress and weather observations such as windshear and turbulence; to request ground-based assistance; and to obtain weather, airspace, and traffic advisory information. Today, these exchanges are conducted solely through voice communications. In the future, they will be conducted by data link as well as by voice.

Navigation and landing services provide aircraft with position information relative to a known location or fix. Guidance signals allow a pilot to fly along a planned route and to comply with clearances received from air traffic controllers. The precision with which an aircraft can follow a planned route and altitude is the dominant factor in determining safe lateral spacings between air routes. Landing aids allow two types of instrument approaches to the runway. With nonprecision approaches, lateral guidance may be provided either by an en route navigational aid or a landing aid when higher accuracy is required; vertical guidance is obtained from the aircraft altimeter and visual aids. For precision approaches, lateral and vertical guidance and distance data with respect to the runway orientation are provided by special landing aids. Lighting systems are also provided to assist the pilot during low-visibility and nighttime operations.



LORAN C Navigation System

Surveillance services are provided to indicate the actual position of an aircraft. The aircraft position is displayed to the controller so that a picture of the traffic environment may be obtained. Each flight path is then monitored to ensure separation. At present, three methods of aircraft surveillance are used: primary surveillance, secondary surveillance, and dependent surveillance. Primary surveillance uses reflected radar to independently determine the slant range and azimuth of the aircraft. Secondary surveillance is provided when an aircraft with an onboard transponder is interrogated by a radar; this radar determines slant range, azimuth, transponder code (i.e., identity), and aircraft altitude as measured by onboard altimetry. In the case of dependent surveillance, the aircraft reports its position as derived from onboard navigation equipment.

Weather and Flight Services

Weather is a major contributor to airport delays and a cause of aircraft accidents and incidents. The FAA's weather services role consists of the collection of aviation-related weather data and the dissemination of those data to air traffic controllers and aviation users. Information on hazardous weather conditions, such as wind shear, gusts, thunderstorms, and poor visibility, is required by controllers and pilots for safe departure and landing. In addition, pilots need information on severe weather, turbulence, and icing in order to avoid these hazards en route.

Remote Sensors for Type of Precipitation

Flight services support the preparation of flight plans by aircraft operators and pilots. Prior to a flight, the operator or pilot obtains a weather briefing describing the weather conditions along the planned route and a report on the operational status of navigational aids along that route. When planning has been completed, a flight plan may be filed to facilitate flow management and separation services; this must be done for flights conducted under instrument flight rules. Flight plans also aid search and rescue operations in the event an aircraft is late or overdue at its destination. Flight services can be initiated or updated through air-ground communications during the course of a flight.

3.2.2 FAA Safety and Security Responsibilities

FAA safety-related responsibilities comprise all certification, regulatory, and enforcement activities with regard to airmen and schools, aircraft, air carriers, airports, and nonfederal air navigation facilities, as well as services for aviation medicine and aviation security.

Multiple New Types of Wind and Ice Detectors Being Tested

Airmen and Schools

Pilots, flight instructors, flight crews, and flying schools are licensed and periodically evaluated according to standards set by the FAA.

Aircraft

Aircraft certification involves the development and administration of safety standards for aircraft, engines, propellers, and avionics. The FAA establishes standards for the design and manufacture of all new aircraft and certifies that aircraft have met these standards before being introduced into service. Airworthiness standards prescribe explicit flight, structural, design, construction, powerplant, and equipment requirements. In addition, the FAA sets guidelines for aircraft maintenance and repair procedures.

Air Carriers

New air carriers must meet FAA aircraft and maintenance standards and follow approved training programs for flight crews and maintenance personnel. Continuing FAA inspections of each airline's operations and maintenance functions are routinely conducted. These inspections typically include aircraft spot checks; flight crew observation; and a review of maintenance crew procedures for overhaul and inspection.

Airports

Airport safety centers on the Airport Certification Program, which involves the licensing and inspection of all airports which handle scheduled services for aircraft with more than 30 seats ("Part 121" aircraft). The program requires airports to meet minimum standards for equipment and operations and to develop procedures to minimize loss of life or property in the event of an emergency. Airport certification standards apply to airport pavement and lighting conditions, self-inspection procedures, firefighting and rescue, bird and wildlife control, security, and other aspects of airport operations.

Air Navigation Facilities

The FAA sets standards for, certifies, and inspects nonfederal public-use air navigation facilities such as state or privately owned instrument landing aids. In addition, the FAA develops, installs, and operates instrument landing systems (ILSs), microwave landing systems (MLSs), and very high frequency (VHF) omnidirectional range tactical aircraft control and navigation.

Aviation Medicine

Aviation medicine addresses medical standards for flight crews and FAA personnel, the improvement of controller and pilot performance in the field, and methods for recruiting and retaining the right personnel for various positions. More recently, aviation medicine is encompassing research on the effects of automation on aircrew and controller performance.

Aviation Security

The goal of the civil aviation security program is to protect against terrorist and other criminal threats. FAA security services include the development of standards for explosives detection, weapons detection, and airport security, and the use of onboard air marshals for international flights.

3.2.3 FAA Technical-Assistance Responsibilities

Under the Airport Improvement Program financed by the Airport and Airway Trust Fund, the FAA manages and allocates planning and development grants to airport authorities for facilities improvements. These grants are provided for landing runways and taxiways, airport lighting, noise-control measures, terminal buildings, and safety and security equipment. The

Airport Capacity Enhancement Program provides funding for activities such as capacity enhancement task forces at specific airports.

3.2.4 FAA International Coordination Responsibilities

Through the International Civil Aviation Organization, the FAA negotiates for the United States with foreign countries on international standards for air traffic operations, equipment, and safety. Specific activities include the standardization of ATC procedures and navigational aids.

3.3 The National Airspace System Facilities and Equipment Plan

The purpose of the ongoing NAS F&E Plan is to upgrade and modernize ATC and airways facilities through a total systems approach. The plan represents an evolving FAA response to an ever-changing aviation environment; though 90 percent of the original NAS F&E Plan projects are under contract or completed, new programs are being continually introduced.

The FAA's RE&D program has supported the NAS F&E Plan since its inception. Indeed, many of the improvements being implemented today are a direct result of RE&D efforts of the 1970s. As the NAS F&E Plan evolves, new opportunities for enhancing ATC and airways facilities services will become available.

This section presents projections of the state of the ATC and airways services facilities and equipment in the mid-1990s. Such projections are an essential benchmark for current RE&D planning directed at future aviation system improvements.

The facilities and equipment included in the NAS F&E Plan have been separated into five categories: (1) en route and terminal air traffic control; (2) communications, navigation, and surveillance systems; (3) weather and flight services systems; (4) interfacility communications systems; and (5) maintenance and operations support.

3.3.1 En Route and Terminal Air Traffic Control

The advanced automation system (AAS) will be the foundation of the air traffic management system of the 1990s. Flexible in design, this system has been developed to easily accommodate future expansion and changing requirements. The AAS will process navigation, surveillance, weather, and flight data in real time, thereby enhancing the controller's ability to strategically and tactically manage the flow of air traffic.

By the mid-1990s, the AAS will have incorporated early versions of automated en route ATC (AERA), which will support controllers in the detection and resolution of aircraft conflicts and the evaluation of alternative air routes. The AAS will have been enhanced by the functions of the advanced traffic management system (ATMS). The ATMS aircraft situation display and monitor-alert function, for example, will improve air traffic controllers' abilities to project traffic delays and assess alternative flow management strategies.

The 21st-century AERA system will utilize artificial intelligence techniques to search for conflict-free flight paths. The system should be able to resolve multiple conflicts, and do so more rapidly than the human air traffic controllers.

3.3.2 Communications, Navigation, and Surveillance Systems

The present air-ground, VHF voice communications facilities will by the 1990s have been augmented with a Mode S digital data link. The data link will provide a discrete addressability capability through the utilization of a surveillance radar system and onboard beacon and will complement the sometimes unreliable VHF network.

Satellite-based digital data links will supplement line-of-sight digital communications networks in those oceanic and underdeveloped areas where ground-based links are not available.

In the navigation area, global positioning system (GPS) satellites will serve as supplemental aids for civil aviation; the issue of GPS integrity as a sole-means navigation system will remain open. LORAN C navigation services will be provided on a national basis in low-altitude, remote, and offshore areas in the absence of other navigational aids. MLSs, which allow multiple, curved, and segmented approaches, will be installed at selected airports and jointly used with ILSs.

For enhanced surveillance, coverage by airport surface detection equipment will be augmented with automated radar tracking and target classification. Mode S identification and data link will be used to improve airport surface traffic surveillance and communications. The result will be increased airport capacity and reduced workload for controllers responsible for the movement of taxiing aircraft and supporting ground vehicles. Automatic dependent surveillance systems will be used to establish the position of aircraft flying over underdeveloped, oceanic, and low-altitude areas. This system will be based on the satellite air-ground communications data link discussed above. Aircraft position data will be derived from onboard navigation systems and altimetry and will be automatically transmitted to a central air traffic control center at regular intervals. Global aircraft situation displays will be located at major ATC centers around the world.

3.3.3 Weather and Flight Services Systems

The prediction, processing, and dissemination of weather information will be enhanced by systems that will provide the aviation community with near-real-time data derived from a variety of weather sensors. Advanced terminal and Doppler weather radars will be installed to more accurately detect microbursts, gust fronts, wind shifts, and precipitation.

Air-ground exchanges used by pilots to report flight progress and obtain air traffic advisory information will be facilitated by digitized data links. Information will be transmitted through both synthesized voice and advanced cockpit displays.

3.3.4 Interfacility Communications Systems

An interfacility communications network will be in place that utilizes a mix of owned and leased switching and transmission facilities, including ground- and satellite-based equipment. Airport telecommunications will have been modernized using fiber optics.

3.3.5 Maintenance and Operations Support

The FAA's ATC and airway facilities maintenance operations will be automated. Sensory and control functions will be provided at remote facilities, enabling equipment certification to be performed from centralized work centers. Instruction and training for operations and maintenance personnel will be accomplished through advanced computer-based teaching techniques.

The facilities, systems, and services brought about by the NAS F&E Plan will together compose a new operational infrastructure for the FAA. This infrastructure will carry the agency up through the 21st century, serving as the primary vehicle for response to changing requirements. As forces within the aviation system emerge, new demands will be placed on the system. Many of these demands, such as those discussed next in Section 3.4, will require more than an operational solution.

3.4 Driving Forces for a Changing Aviation System

The national aviation system is currently being driven by a number of forces, including an increasing demand for air travel, the application of advanced aviation technologies, and threats to security posed by terrorism and other criminal acts. The FAA's RE&D Plan is an essential means for meeting these current and future challenges.

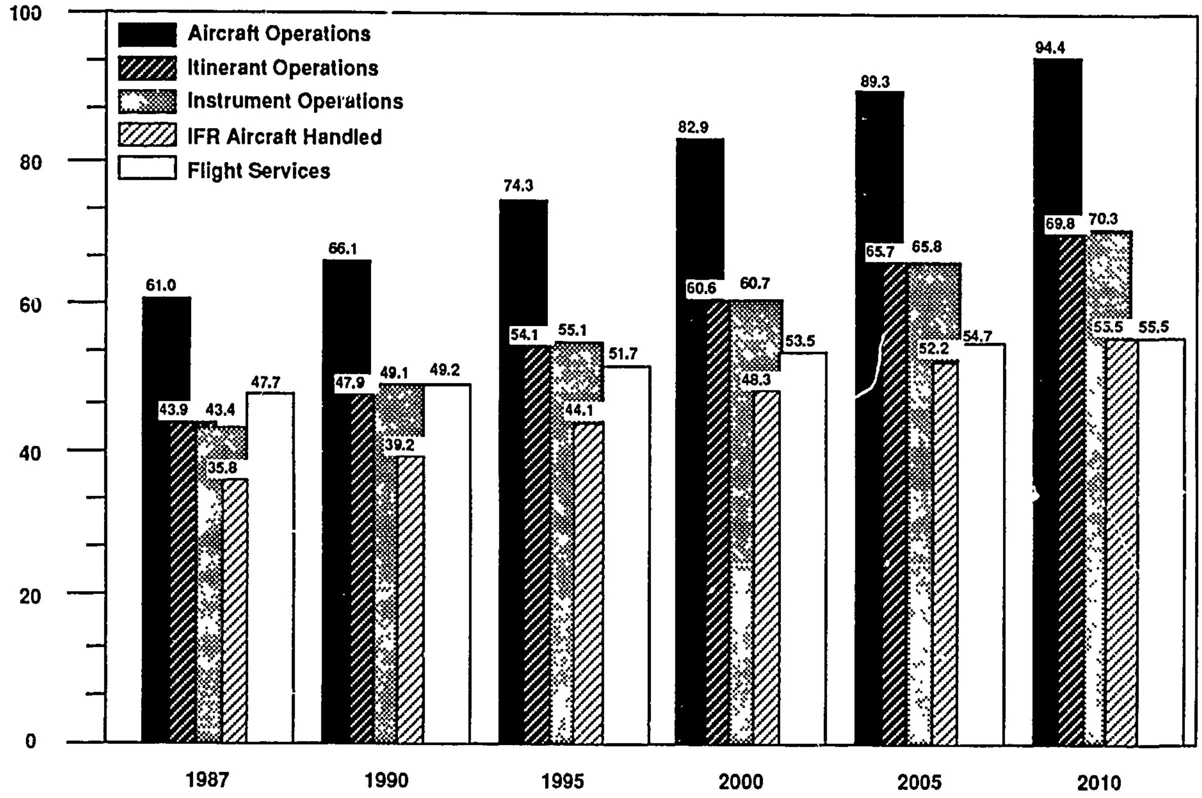
3.4.1 Increasing Demand for Commercial Aviation

Over the past decade, commercial aviation has witnessed extraordinary growth. This growth is the result of route flexibility and competitive fares brought about by economic deregulation, a recently booming economy, and the increasing reliance of global service and manufacturing industries on air transportation. As shown in Figure 3-1, domestic passenger enplanements in scheduled service increased from less than 250 million to 450 million annually between 1977 and 1987. By 1990, this figure is expected to exceed 500 million.

These trends will continue over the next 2 decades. Domestic enplanements are expected to reach 800 million in the year 2000 and exceed a billion by 2010, representing increases in air carrier and commuter enplanements of 129 and 272 percent respectively. Other examples of growth anticipated up to the year 2010 include a 55 percent increase in aircraft operations, including takeoffs and landings at towered airports; a growth of 62 percent in instrument operations in terminal areas; a 73 percent increase in air carrier hours; and respective increases of 62 and 75 percent in the air carrier and commuter fleets. (See Figures 3-2 through 3-4.)

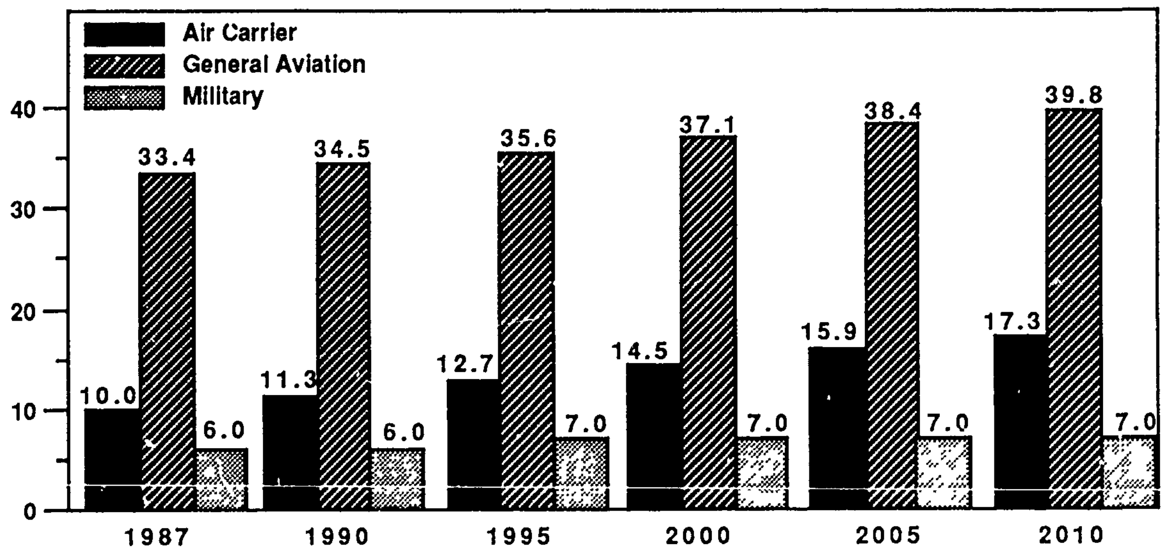
Source: FAA Long-Range Aviation Projections, Fiscal Years 2000-2010, June 1988.

FIGURE 3-1 – DOMESTIC ENPLANEMENTS IN SCHEDULED SERVICE (MILLIONS)



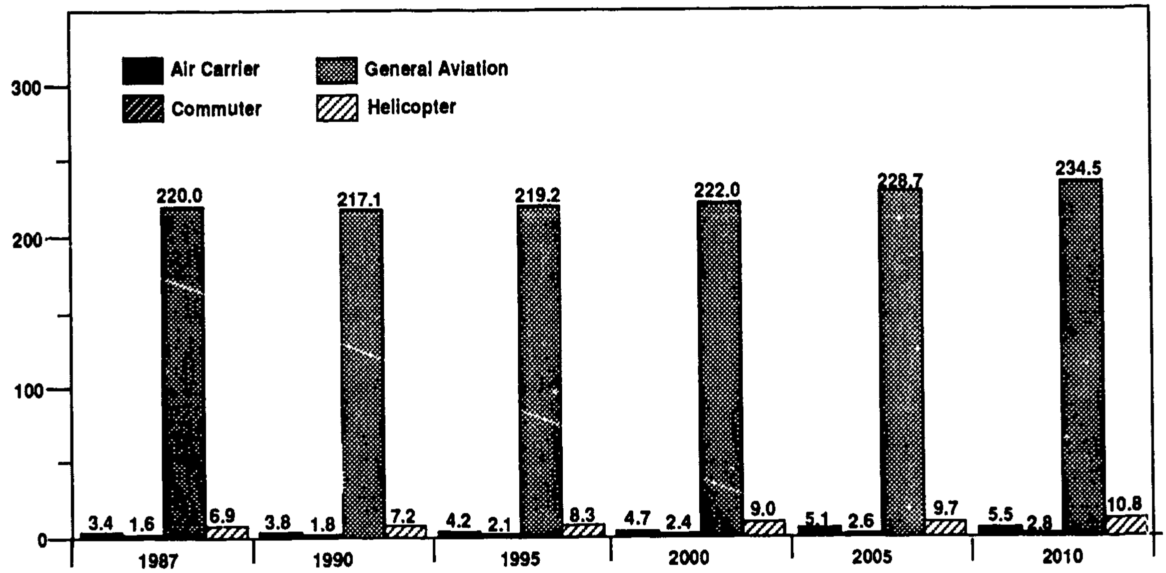
Source: FAA Long-Range Aviation Projections, Fiscal Years 2000-2010, June 1988.

FIGURE 3-2 -- OPERATIONS AT FAA FACILITIES (MILLIONS)



Source: FAA Long-Range Aviation Projections, Fiscal Years 2000-2010, June 1988.

FIGURE 3-3 -- AIRCRAFT HOURS FLOWN (MILLIONS)



Source: FAA Long-Range Aviation Projections, Fiscal Years 2000-2010, June 1988.

FIGURE 3-4 – AIRCRAFT FLEET SIZE (THOUSANDS)

Congestion and Delay

The congestion and delay problems experienced today are a result of a steady growth in commercial aviation without expansion of the nation's airport system. No new airports have been constructed to meet demand, and new runways have not been added at many capacity-constrained airports near major metropolitan areas. Since deregulation, the increase in demand for aviation services has placed a substantial burden on the airport and air traffic system. The nation is currently paying the price, through delay, for lack of expansion in airport capacity.

In the competitive environment which followed deregulation of the airlines, carriers tried to maximize the number of seats filled by eliminating unprofitable routes, concentrating instead on more lucrative, high-density routes. The hub-and-spoke system of scheduling and marketing established a number of routes connected to a central hub. Passengers could be collected from feeder flights in smaller aircraft, transferred to other flights on the same carrier, and then transported to their ultimate destination on larger aircraft.

While the hub-and-spoke system is a sound marketing strategy to maximize air carrier profits, it has resulted in tightly scheduled arrivals and departures, which contribute to delay. In 1987, twenty-one airports exceeded 20,000 hours of annual air carrier delay; 35 airports are expected to do so in 1997. (See Table 3-1.) Delays have become commonplace at some of the major hubs, including Atlanta, Chicago, and Los Angeles, particularly during peak hours or periods of bad weather.

Currently, the 27 busiest airports enplane approximately 74 percent of all passengers. The FAA considers 13 large airports to be congested and expects an additional 34 to experience

TABLE 3-1 – AIRPORTS EXPECTED TO EXCEED 20,000 HOURS OF DELAY BY 1997

AIRPORTS		1987 HOURS	1997 PROJECTED HOURS
		(Thousand Annual Hours Delay)	
ATL	Atlanta Hartsfield	75-100	100+
BNA	Nashville Intl.	10-20	20-50
BOS	Boston Logan	20-50	50-75
CLE	Cleveland Hopkins	10-20	20-50
CLT	Charlotte Douglas	10-20	20-50
CMH	Port Columbus	10-20	20-50
CVG	Greater Cincinnati	10-20	20-50
DCA	Washington National	20-50	20-50
DEN	Denver Stapleton (see note)	50-75	100+
DFW	Dallas - Ft. Worth	75-100	75-100
DTW	Detroit - Wayne County	20-50	20-50
EWR	Newark Intl.	20-50	75-100
HNL	Honolulu Intl.	20-50	20-50
HOU	Houston Hobby	10-20	20-50
IAD	Washington Dulles	20-50	50-75
IAH	Houston Intercontinental	20-50	20-50
JFK	New York Kennedy	20-50	50-75
LAS	Las Vegas McCarran	10-20	20-50
LAX	Los Angeles Intl.	50-75	75-100
LGA	New York LaGuardia	20-50	50-75
MCO	Orlando Intl.	10-20	20-50
MEM	Memphis Intl.	10-20	20-50
MIA	Miami Intl.	20-50	75-100
MSP	Minneapolis - St. Paul	20-50	20-50
ONT	Ontario Intl.	10-20	20-50
ORD	Chicago O'Hare	100+	100+
PHL	Philadelphia Intl.	20-50	50-75
PHX	Phoenix Sky Harbor	20-50	50-75
PIT	Greater Pittsburgh	20-50	20-50
SEA	Seattle - Tacoma	10-20	20-50
SFO	San Francisco Intl.	20-50	50-75
SJC	San Jose Intl.	10-20	20-50
SLC	Salt Lake City Intl.	10-20	20-50
STL	St. Louis Lambert	20-50	50-75
TPA	Tampa Intl.	10-20	10-20

Note: Based on the Standardized Delay Reporting System from three major carriers. Predictions for 1997 assume approved airport improvements made. Prediction for Denver in 1997 assumes no new airport.

Source: FAA Office of Aviation Policy and Plans, 1988.

significant delays by the year 2000. In total, the FAA expects 58 airports (47 of them large hub airports), handling 76 percent of all passengers, to be congested by the turn of the century.

The prospects for increasing commercial airport capacity are limited. Due to high costs, public resistance, and local government regulations, it is not likely that many new major airports will be built in the near future. (The last major commercial airport built in the U.S. was Dallas-Ft. Worth in 1973.)

Construction of new runways or aircraft gates also requires large financial and land-use commitments. Because of aircraft noise, proposals for new airports, runways, and extended operating hours outside of local curfew times generally are met with strong local opposition. Technically feasible alternatives which can enhance existing airport capacity during instrument flight conditions are needed which will in the near term address growing demand. These technological advances will not, by themselves, be able to keep pace with projected growth in demand; however, some of the advances may allow certain airports to overcome resistance to expansion through better utilization of existing runways.

3.4.2 Technological Advances

The next decade will bring about substantial changes in aviation technology and design as the potentials for greater aircraft speed and efficiency are explored. Developments such as the use of advanced materials for aircraft construction and the emergence of new, high-speed aircraft engines will require continuous FAA oversight to ensure that efficiency is not gained at the expense of safety. The FAA will also be charged with developing the systems and operations necessary for realization of the advanced automation concepts planned for the aviation system of the future.

Advanced Aircraft Materials

Many new types of advanced materials may be used in the construction of future aircraft. Composite materials, for example, offer superior strength and stiffness properties, as well as lighter weight and resistance to corrosion and other weathering effects.

While these materials may offer significant benefits in terms of strength and weight, the full implications of their use in aircraft and their "crashworthiness" are of concern. One issue is the increased damage potential of electromagnetic hazards for aircraft constructed of composite materials, especially those using fly-by-wire control systems.

New Propulsion Systems

New subsonic engines now beginning flight tests or in late design stages will provide airlines with dramatic improvements in fuel economy. The expected range of performance characteristics for aircraft and rotorcraft operating in the near future is shown in Table 3-2. The trend for air carriers is expected to be toward high-speed aircraft operating at higher altitudes and expanded ranges with the same payloads. Supersonic transports with speeds of mach 2.5 to 3.5 will begin to enter the fleet around the year 2000, with hypersonic (greater than mach 5) and transatmospheric flight possible by 2010.

The application of advanced technology propulsion systems brings its own set of problems and hazard potentials that the FAA's specialists must be prepared to resolve. These include takeoff noise, sonic boom, and possible depletion of the ozone layer. Wide variations in aircraft operating characteristics will also add to the complexity of the aviation system, especially in congested areas.

Turbine rotor containment is of increased concern because of the rapid growth in turbine-powered helicopter use. Compared to transport aircraft, multi-engine helicopters are forced by design to have turbine engines in close proximity to each other, to critical rotor gearing and controls, and to the top of the fuselage, with little space available for shielding or isolation. Consequently, the threat of high-energy metal fragments from uncontained turbine-engine rotor failures requires additional research on protective measures.

Automation Opportunities for the Future

By the year 2010, a great number of automation advances are expected to be made. The flow of information to operators and the ATC system will have been enhanced by widespread use of digital data-link communications. Dynamic knowledge of system and airport capacity will have become good enough to permit a great deal more strategic planning than exists in the system today.

TABLE 3-2 -- RANGE OF AIRCRAFT PERFORMANCE - NEAR TERM (1989 TO 1995)

Type of Aircraft	Cruise Speed (mph/mach)	Cruise Altitude (feet)	Range (statute miles)	Approach Speed (mph)	Takeoff Length (feet)	Landing Length (feet)	Trend Forecast
Civilian Air Carriers	300-M0.8	10,000-65,000	1000-8400	100-180	3200-11,500	2300-7000	For air carriers the trend is toward aircraft with greater fuel efficiency operating at altitudes to 100,000 feet and ranges to 10,000 miles. Beginning around the year 2000, there will be a limited number of SST flights. Beyond that, hypersonic and transatmospheric flights are possible.
General Aviation/Business	150-300	5000-40,000	700-1500	50-90	80-3000	700-2500	For general aviation/business aircraft, the trend is toward smaller aircraft operating at higher altitudes for greater fuel efficiency.
Turbine-Powered Business	210-M0.8	8000-55,000	1300-4800	90-160	1600-5800	1500-4700	
STOL	130-M0.7			50-90	600-2300	700-1700	
VTOL/STOL	300-M0.9	50,000	to 2000				
Rotary Wing	95-290	2000-18,000	250-1200				Advanced blade concept rotors will increase rotary wing speeds to 300 mph.
Tiltrotor	300 +		200				Convertible engines and folding rotor blades will enable higher speeds and longer range.
Military Transport/Bomber	260-M1.2	10,000-65,000	1500-7500				Some hypersonic, transatmospheric cargo, and reconnaissance flights are possible in the 2005 to 2015 time period.
Attack/Fighters/ Reconnaissance	600-M3.0	to 100,000	70-750				
Military Training/Utility	200-M1.2	5000-40,000	300-1500				

The ATC system, which is today a balance of strategic and tactical operations, will have shifted to permit more strategic planning and will be far more capable of adapting to changing traffic situations. Through capabilities brought about by AERA and other systems, the ATC process will be far more automatic than it is today, eventually permitting the creation and transmission of conflict-free, fuel-efficient clearances. AERA and the flow management system will have been merged into a single system extending from en route operations to the departure and arrival phases in the terminal areas at major airports.

Cockpit systems that can simplify and optimize the interaction of pilots with automated systems and digital communications devices will be in widespread use. Many aircraft will fly precisely enough to work within narrow metering "windows" established by air traffic control for more efficient use of airport and airspace resources.

Traffic density will be so high and the vehicles so varied that discipline, by common consent, will increasingly be necessary in high-density airspace to achieve safe and efficient operations for all users. Information flow and traffic management at the lower altitudes will become more critical because of increased numbers of rotorcraft and tiltrotor aircraft. As aircraft enter higher density airspace from low-density airspace, they will automatically become part of the controlled system, communicate their intentions if they have not done so before takeoff, and remain controlled to the extent necessary to ensure separation and avoid conflicts.

Control systems for very high altitudes will come on the scene to permit safe management of aircraft operating in the supersonic and, possibly, hypersonic regimes. While the basic process of air traffic control is not likely to change, management of such aircraft will require special handling, probably through the use of large area coverage, very high altitude centers, and international or multinational control.

The concept of visual flight rules operations will remain viable, but will be enhanced by airborne collision avoidance systems that will warn aircraft of impending conflicts and intervene, if necessary, to prevent them. Virtually all aircraft will have access to real-time weather data and other flight information, much of it via digital data link.

3.4.3 Perception of Risk

The U.S. aviation system is the safest in the world. Despite a 26 percent increase in aircraft departures since 1978, fatal accidents for air carrier and commuter operations have continued to decline from 59 in the 1975 to 1978 period to 51 between 1979 and 1982 and 32 from 1983 to 1986.

However, regardless of this strong safety record, a number of recent accidents and near-accidents have prompted a widespread perception of a growing safety problem. Some aviation users argue that accident statistics may not reveal a subtle deterioration of the system's margin of safety. Nowhere are such concerns greater than in the areas of aging aircraft and pilot and controller performance.

Aging Aircraft

The April 1988 Aloha Airlines incident, in which a 15-foot section of a plane's upper fuselage was suddenly ripped during flight, heightened a growing concern among airlines, aircraft manufacturers, the U.S. Congress, and the traveling public about aging aircraft.

Several issues will need to be addressed if the growing aging aircraft problem is to be contained. These include investigations of the causes of major structural failures, adjustments to maintenance and inspection programs, improvements in current nondestructive testing technology, and enhancements of communications within the aviation community.

Human Performance

Recently publicized accidents and incidents have prompted a renewed awareness of the importance of human performance in aviation safety. Although the total accident rate for large commercial aircraft has decreased over the past few years, human error is still a factor in more than 65 percent of commercial aviation incidents. The problems and issues impacting personnel performance are therefore of significant concern to the FAA, including such areas as pilot and controller training, work shifts, job stress, and the automation of the cockpit and ATC system.

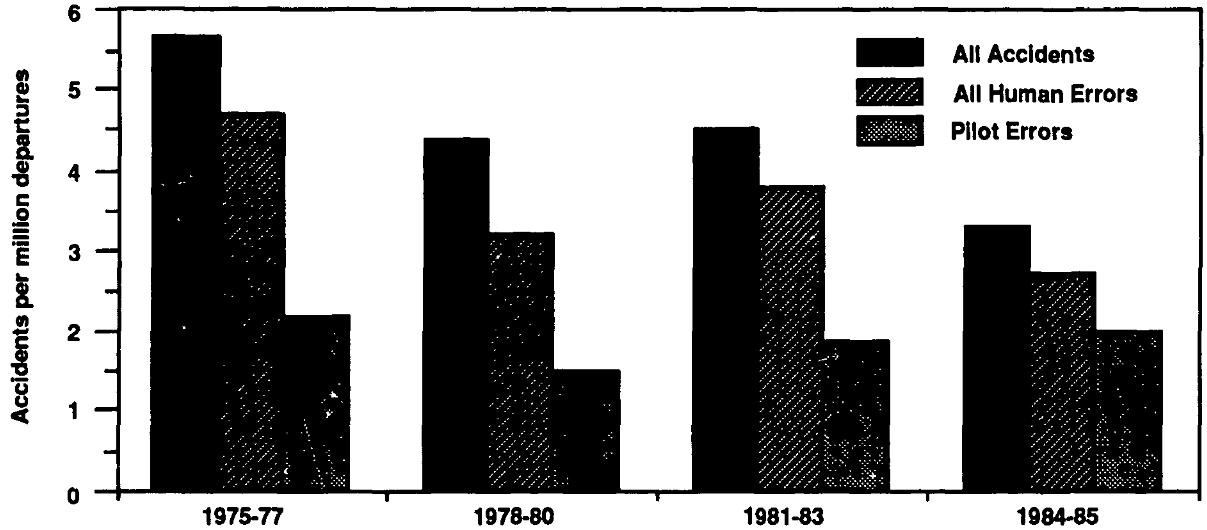
Pilot Training

As shown in Figure 3-5, pilot causes predominate among human error-related accidents. Much attention is therefore being paid to pilot qualifications and training programs, which are monitored by the FAA.

The rapid growth of commercial air service since deregulation has created a shortage of qualified pilots; the number of new private pilot certificates issued each year has decreased from 58,000 in 1978 to only 35,000 in 1986. One result has been the rapid advancement of new crew members to the position of captain, without the accrued flight hours typical of the past. Furthermore, although the role of the pilot has been dramatically altered by modern cockpit technology and other factors, pilot training programs have not been evaluated for several years. If pilot errors are to be reduced, the entire pilot training and rating system will require reexamination and revision so that they may be brought up to date with current technologies and procedures.

Controller Selection and Training

To counteract a shortage of air traffic controllers, the FAA has stepped up its candidate training. However, too many trainees are dropping out before completing all requirements for the position. If more qualified candidates are to be attracted, controller selection criteria will need to be reevaluated and revised. Training programs for both new and existing controllers should also be restructured to enable faster progress and improved adaptation to an automated work environment.



Source: Office of Technology Assessment based on National Transportation Safety Board data, 1975-85. Data from 1986 and 1987 are not yet available.

FIGURE 3-5 -- PART 121 TOTAL AND HUMAN ERROR ACCIDENTS

Work Shifts and Job Stress

With the increased level of traffic since deregulation, the possible effects of shift work and job stress on the performance of pilots, controllers, and maintenance technicians have become exacerbated.

Shift work has and always will be a requirement for operation of the national aviation system, which operates around the clock, 7 days a week. Questions of fatigue; personnel performance; and health, safety, and job satisfaction all revolve around the proper management of shift rotation and scheduling. Compounding the effects of shift work are the morale problems brought about by such factors as rapid changes in workload.

Automation Interfaces

With the impending implementation of the AAS and various cockpit automation systems, the interface of pilots and controllers with advanced automation devices is of primary concern. While automation will inevitably have positive payoffs in a number of areas -- including reduced workload, more efficient performance, and increased capacity -- it is important that the potential benefits do not overshadow safety concerns. Before an automation improvement can be successfully implemented. it must be evaluated from an applied as well as a theoretical point of view.

Recent advances in cockpit automation and design have the potential for minimizing or even preventing human error by reducing pilot workload. However, although automated devices such as the autopilot can provide greater efficiency, operational errors involving this equipment remain an area for concern. The potential for these errors (e.g., misinterpreting an electronic display or keying in incorrect information) need to be evaluated and quantified. Certification procedures will also have to be updated to address the interface of crew members with advanced cockpit electronic systems and to distinguish this equipment from other aircraft hardware.

Significant advances have also been made in the area of air traffic automation. As a result, the controller of the future is likely to have a considerably different role than that of today's specialist. The controller's job is now characterized by the need for active and often continual verbal interaction with both pilots and other controllers. With the automated ATC system planned for the near future, much less of the controller's workload will be interactive. These future concepts may reduce controller workload to such an extent that boredom or inattention may result, with system failures or inadequacies going unnoticed.

3.4.4 Terrorism and Other Criminal Acts

Today's rapid growth in commercial air travel has been shadowed by a significant rise in terrorism. Since 1985, the terrorist threat has become more sophisticated and dangerous. Countries sympathetic to various causes have been providing terrorists with modern weapons, explosives, and shelter for their activities. A major FAA goal is to provide passengers with the same high level of security against terrorists as it does against other hazards. For the future, this will mean a continued emphasis on the development of new systems for explosives and weapons detection and the enhancement of overall airport security.

Explosives Detection

The advent of new terrorist tools, including difficult-to-detect explosives, poses an increased threat to in-flight security. The development of new detection devices for explosives in baggage and air cargo will, therefore, be necessary to maintain and increase passenger safety.

Weapons Detection

Gun manufacturers are beginning to use new composite materials, such as fiber-reinforced plastics and lightweight ceramics, to replace steel components. In addition, the dramatic growth in traffic means that there are more passengers who will have to be screened for these sophisticated weapons. These factors combine in making the FAA's security task even more challenging.

Airport Security

As a result of potential terrorist and criminal threats, the present level of airport and concourse security is being reassessed by the FAA. To ensure total airport invulnerability while accommodating increasing demand, security will have to be upgraded in all areas of the airport -- from the outer perimeter to the boarding jetways -- without impeding the fast-moving, high-density flow of passengers and airport operations.

These and other challenges facing the FAA are major influences on the current RE&D program. This plan is discussed in detail in Chapter 4.

4. The RE&D Program

4.1 Overview and Orientation to the RE&D Plan

The FAA is committed to a new direction for its RE&D program and for the manner in which the agency prioritizes and allocates RE&D resources. The new program will meet the challenges of the changing aviation environment described in Chapter 3 by emphasizing a careful balance between support for the FAA's safety, security, capacity, and efficiency missions. RE&D emphasis has shifted from support of the initial National Airspace System (NAS) Facilities and Equipment (F&E) Plan to NAS F&E Plan enhancements and other programs that will meet current and long-term needs.

Section 4.2 of this chapter introduces the FAA's new top-down, goal-oriented RE&D planning process. Actions taken in response to the goals of Impact 88 and recent concerns of Congress and the aviation community are described in Section 4.3. Section 4.4 presents the relationship between the new RE&D program and the NAS F&E Plan, and Section 4.5 presents additional RE&D opportunities. Descriptions of the individual projects which compose the RE&D program are provided in Volume II.

4.2 Major Mission Areas - A Top-Down Approach to RE&D

A key element of the FAA's new approach is the concept that RE&D is a major vehicle for evolutionary change within each of the agency's fundamental mission areas -- capacity, safety, security, and efficiency. These four major mission areas now form the principal framework for analyzing RE&D requirements, setting project goals, and measuring performance improvements. This approach represents a departure from a longstanding precedent which placed emphasis on technical elements, with air traffic control (ATC) system technology as the central consideration. It also is intended to increase understanding of the relationships between RE&D projects and anticipated impacts on mission objectives.

The RE&D program is intended to support all major mission areas, recognizing that many projects will and should support multiple objectives; interdependencies among aviation system capacity, safety, and efficiency are acknowledged to be especially strong, frequently involving compensating trade-offs in one area for gains in another. A comprehensive set of measurable parameters or measures of effectiveness (metrics) are to be developed within the mission area framework to help provide a basis on which to quantify the benefits of RE&D projects such that each will have goals directly related to the furtherance of one or more major mission area.

The concept of using metrics for the planning and management of the RE&D program is introduced in this edition of the FAA RE&D Plan. By incorporating indices of change in the national aviation system, the FAA intends to further its objectives of program effectiveness, as well as demonstrate a new approach to accountability for RE&D resources and opportunities. In the sections that follow, a number of candidate metrics are identified. Because of time limitations, this edition presents only the concept and examples of metrics for each of the major mission areas. In the future, it is envisioned that quantitative metrics will be used in the assessment of new initiatives, although the development of metrics varies for each of the mission areas. For example, while airport capacity measures have been studied for many years, improved aviation safety indices are currently the subject of special studies, and other metrics are now only tentatively identified.

The balance of this section presents the overall RE&D objectives for the major mission areas and identifies products of RE&D projects which support these objectives. Tables list supporting projects for each of the elements within the mission areas. Included in these tables are the anticipated RE&D products and an indication of whether benefits are expected to be realized in the near term (now to 1995), mid-term (1996 to 2005), or far term (2006 to 2015). Project numbers, titles, and products reference those contained in Volume II of this plan.

4.2.1 The Capacity Mission

Inadequate capacity is one of the most serious problems facing the aviation industry. Insufficient airport capacity will limit the number of aircraft that can use an airport during a given time period. Insufficient airspace capacity will force aircraft to use alternate, less efficient routes, and may in some areas restrict the number of aircraft operations per hour and prevent aircraft from using available airport capacity.

Present-day capacity limitations are threatening the ability of our nation's airport and airways system to keep pace with the economy. In view of the many accepted forecasts projecting a continuing increase in system demand for at least the next 10 years, it is widely believed that capacity limitations will continue to be a major challenge to sustained air commerce growth. Capacity enhancement is, therefore, a major mission of the FAA and a primary focus of many important RE&D projects.

The overall objective of RE&D in this area is to identify, develop, and evaluate facilities, systems, and procedures to safely enhance or expand airport and airspace capacity. The near- and mid-term challenge is to address present-day capacity limitations by using NAS F&E Plan infrastructure, technology, and procedural changes to best utilize existing facilities. Far-term capacity-expansion RE&D is planned to address capacity requirements for the national system of airports and airways into the 21st century through major capital investments in new airports and control systems. The primary metric for evaluating the effectiveness of capacity-enhancing RE&D projects is the change in the number of aircraft operations in a given time period for fixed environmental conditions, or operational throughput.

The problem of congestion in the airspace is different from that of airports. At the airport, insufficient capacity means that the growth of traffic is limited to a certain number of aircraft per hour. In the airspace, insufficient capacity on an air route means that aircraft must fly on nonpreferred, alternative routes. While insufficient airspace can limit growth in traffic until new routes are established, the main problem is that it makes it more costly to fly between two points in terms of time and fuel consumption. The primary goal of airspace capacity RE&D is to develop ways to accommodate increased traffic in a given volume of airspace, thereby minimizing the amount of nonpreferred routing caused by congestion. For airport capacity RE&D, the major objective is to increase the capacity of the airport system; if used according to existing operating procedures, the number of runways in major metropolitan areas will not be able to safely accommodate the projected traffic demand over the next 10 years without extensive delays.

The capacity-enhancement portion of the FAA RE&D program is focused on achieving the following kinds of improvements: better management of arrival traffic flows of landing aircraft and better planned runway exits to be able to reduce interarrival time and runway occupancy time variability; shorter runway occupancy times to permit improvements in departure separation (distance or time) standards; better knowledge of wake vortices; improvements in surveillance capability and other ATC functions to permit instrument approaches to be conducted independently at parallel runways separated by as little as 2500 feet; and simultaneous approaches to converging runways to be conducted under instrument conditions while assuring that aircraft might still execute simultaneous missed approaches. A breakdown of the elements and subelements of this major mission area is shown in Figure 4-1.

Airport Capacity

The RE&D program presents a systematic way to identify the specific improvements in ATC system performance to achieve a desired increase in the number of possible aircraft movements. It also systematically identifies the obstacles to improving ATC system performance in order to focus RE&D on the most effective projects.

Demand for access to major airports serving the scheduled air carriers continues to increase faster than the ability of these airports to meet the demand. During 1987, over 450 million passengers and billions of dollars worth of cargo were carried. Over 80 percent

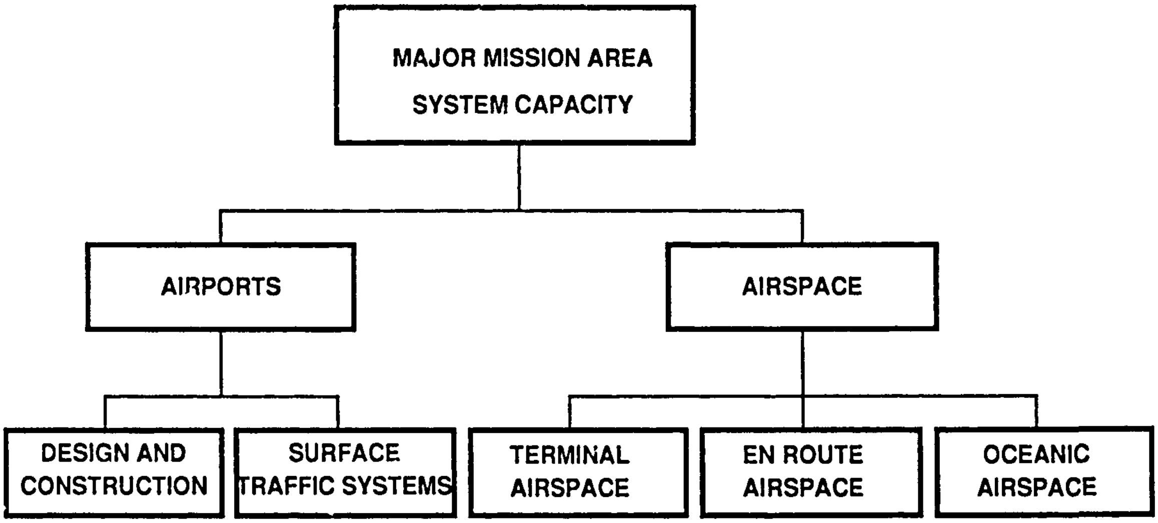


FIGURE 4-1 -- THE CAPACITY MISSION AREA

of passengers moved through the nation's 50 busiest airports. These top 50 airports account for most of the air carrier flight delays. As previously discussed, by 1996, 32 of these 50 airports are forecast to experience more than 20,000 annual delay hours if no improvements in capacity are realized. Operations at these airports are expected to increase by 26 percent, and delays are anticipated to grow by 58 percent, over twice the rate of the increase in demand.

The most effective way to address lack of future airport capacity is through the construction of new runways and airports near the urban areas that currently feed the busiest airports and the development of new technologies and procedures that safely allow more aircraft to use existing runways in adverse weather conditions. The limitations of existing radar, cockpit instrumentation, and automated systems for pilots and controllers combine to limit airport capacity, especially during the arrival phase of flight. When weather reduces visibility, the need to operate under instrument flight rules (IFR) reduces the clear-weather capacity available under visual flight rules (VFR) by as much as 50 percent. When the gap between IFR and VFR capacities is large and the number of users exceeds the IFR capacity, changes in the weather can cause very serious disruptions in service and result in long flight delays. Most of the FAA's RE&D efforts are directed toward closing the gap between IFR and VFR capacities.

The primary determinants of single runway capacity in instrument conditions are the minimum allowable separations between trailing and leading aircraft, referred to as in-trail separations; minimum interdeparture time separations; and average runway occupancy time. The variability of in-trail separation, expressed as interarrival time variability, and that of runway occupancy time also affect the capacity of the single runway, because variability in achieving the minimum required separations results in needless gaps in the arrival stream.

Where multiple runways can be operated simultaneously, several additional factors combine to determine total airport capacity. These factors include lateral separation criteria, surveillance accuracy and update rates, and diagonal separation minima. In instrument conditions, specified minimum separations must be maintained between aircraft landing on parallel approach courses. Where multiple runways exist whose centerlines or extended centerlines are not parallel but, rather, converging and intersecting, procedures must be specified to ensure that approach and missed approach paths do not permit two aircraft on simultaneous approaches to operate too close to one another.

The FAA, in cooperation with the aviation community, is performing RE&D to exploit opportunities to improve capacity at existing airports through projects related to airport design and construction and surface traffic management systems.

Airport Design and Construction

Concepts for reducing runway occupancy times are being developed through the use of improved runway exits, taxiway geometries, and visual aids such as signs and lighting. Resulting designs will be tested in simulators to ensure pilot acceptability and will be demonstrated at specific airports. Sensors for detecting and measuring the amount of water, slush, snow, and ice on runways, as well as improved methods of removing these materials, will be evaluated. A dynamic computer simulation program is being developed for evaluating passenger flows in different terminal building and landside configurations to see how these configurations can enhance airport capacity (Project 10.3).

Environmental constraints, primarily relating to noise, are a major impediment to the growth of airport capacity in the national aviation system. Moving forward from the major advances in engine noise suppression achieved by industry during the past 15 years, FAA RE&D efforts are under way to further ensure reduction of aircraft noise in the vicinity of airports through the use of improved hardware designs, revised certification standards, and effective noise-abatement operating procedures. Improved computer modeling techniques are being developed to assess the effects of proposed local and national environmental constraints. Helicopter noise-reduction programs are being pursued jointly with the National Aeronautics and Space Administration (NASA), the Department of Defense (DoD), and industry. The ways in which aircraft engine emissions degrade air quality around airports is also being examined (Project 10.8).

Under joint FAA/airport sponsorship, task forces are working to identify and recommend airport a. [illegible] erational improvements which can enhance airport capacity. Composed of representatives from the FAA, airports, airlines, commuter and industry groups, and aviation consultants, these airport capacity enhancement task forces analyze technically feasible alternatives for reducing delay. Each site-specific task force also examines the possible benefits of systems and procedures under RE&D development. Since 1987, airport capacity task force efforts have been completed at

J.F.K., Newark, La Guardia, San Francisco, San Jose, Oakland, Detroit, St. Louis, Memphis, and Miami. Task force activities are under way at Boston, Phoenix, Salt Lake City, Kansas City, Washington-Dulles, Seattle, and Orlando, and new task forces are scheduled for Chicago and Los Angeles. Additional runways are being considered at Atlanta, Detroit, and St. Louis as a direct result of airport capacity task force efforts. RE&D funding is used to support modeling and simulation of task force recommendations in order to quantify potential benefits of proposed capacity improvements (Project 10.4).

The reduced land required for vertiports (as opposed to conventional airports) means that rotorcraft, including tiltrotors, will bring more convenient transportation to a larger number of people, provided that a system of vertiports is available to support the anticipated operations. Design criteria are being developed for helicopter and civil tiltrotor landing areas, including advanced lighting and marking configurations (Project 10.7).

A microcomputer-based simulation model is under development for analyzing pedestrian flow through terminal buildings and identifying potential choke points. The model is being provided with a graphical output and will be a useful tool for architects, engineers, and planners involved in the design of new or expanded terminals (Project 10.6).

TABLE 4-1 -- PROJECTS SUPPORTING CAPACITY - AIRPORT DESIGN AND CONSTRUCTION

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
10.1	Pavement Strength, Durability, and Repair	• Pavement Design for Heavy and Advanced Aircraft	Mid-Far
10.2	Airport Safety	• Improved Lighting and Marking	Near
		• Runway Exit Friction Measurements	Near-Mid
10.3	Airport Capacity and Delay	• Exit Designs for Reducing Runway Occupancy Time	Near
		• Airport Designs for Multiple Aircraft Types	Near
		• Snow/Ice Detection and Removal Systems	Near
		• Computer Model for Passenger Flows (Landside)	Near
10.4	Airport Capacity Task Force Studies	• Site-Specific Action Plans	Near
10.5	Airport Capacity Enhancement Planning	• Technology and Procedure Assessments	Near
		• Airport Capacity Enhancement Plan (Annual)	Near-Mid-Far

Continued on Next Page

TABLE 4-1 (CONT.) -- PROJECTS SUPPORTING CAPACITY - AIRPORT DESIGN AND CONSTRUCTION

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
10.6	Terminal/Landside Traffic Modeling	• Improved Models for Evaluating Terminal Designs	Near
10.7	Heliport/Vertiport Design and Planning	• Data for Advisory Circular on Vertiport Planning Guidelines	Near
10.8	Environmental Activities	• Reports on the Prediction and Assessment of Noise Impacts of Advanced Aircraft and Engines	Near-Mid-Far
		• Improved Compatibility Criteria for Land Use Near Noise-Impacted Airports and Heliports	Near
		• Tiltrotor Noise Certification Standards	Near
		• Refinement of International Noise Standards	Near
		• Microcomputer Pollution Model for Airports	Near
		• Microcomputer Noise Model for Heliports	Near
		• Noise/Capacity Trade-Off Model for Examining Impacts of Individual Airport Actions	Near

Surface Traffic Systems

Airport surface traffic congestion can be characterized by the required aircraft ground operating time prior to takeoff and after landing. For a single inbound or outbound aircraft, several tower-to-aircraft messages are typically required, each being the result or cause of critical decisions concerning runway crossings, taxi sequence, holding for route clearance delivery, wake avoidance, or takeoff clearance.

The FAA RE&D program is initiating efforts to automate surface traffic systems, pursuing goals of reduced runway incursions and minimized capacity restrictions attributable to traffic-related ground delays. This is a mid-term effort (1996 to 2005). Automatic radar tracking and target classification, with Mode S identification and data link to each aircraft, will supplement airport surface detection equipment (ASDE) coverage and improve surface traffic surveillance and communications at high-density airports. It will increase capacity and reduce the heavy workload of air traffic controllers responsible for the movements of taxiing aircraft and supporting ground vehicles (Project 6.4). Additional functions targeted for development include multiple airport dependent runway management, for airports within hub areas that are runway- and airspace-interdependent, and automated predeparture queue management for the integration of airport traffic (Project 3.6).

Several projects seek to develop computer models which will be used to enhance airport capacity. Models such as SIMMOD (simulation model development and validation) are currently being used to study surface traffic movements. Work will continue on enhancing these models and adding automated features to make them easier and more efficient to use (Project 2.7).

TABLE 4-2 -- PROJECTS SUPPORTING CAPACITY - SURFACE TRAFFIC SYSTEMS

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
2.7	Simulation Model Development and Validation (SIMMOD)	• Enhanced Simulation of Airports	Near-Mid
3.6	Airport Surface Traffic Automation (ASTA)	• Runway Incursion Detectors	Near
		• Airport Surface Guidance System	Mid
		• Automated Ground Traffic Control	Mid-Far
6.4	Surface Traffic Surveillance	• Applications of ASDE/Mode S for Automatic Tracking on Surface	Near-Mid

Airspace Capacity

The primary goal of airspace capacity RE&D is to develop ways to accommodate increased traffic in a given volume of airspace, thereby minimizing the amount of nonpreferred routing caused by airspace congestion. Three elements of the airspace system are considered in the program: terminal, en route, and oceanic.

Terminal Airspace Capacity

Terminal airspace is the airspace that "connects" en route airspace with airpo runways. It is characterized by transitions in aircraft altitude, heading, and speed. Terminal airspace places a fundamental limit on ATC system capacity because the funneling of traffic flow into final approach zones imposes constraints that cannot be overcome by the use of alternative routings. The primary measure presently used for terminal airspace capacity is the total number of aircraft operations in the terminal area. A principal objective of the FAA's RE&D program is to increase terminal airspace capacity to the point where runway capacity will be the controlling limit of the rate of operations.

Terminal ATC automation (TATCA) promises to contribute greatly to the full realization of this objective. This major effort will develop automation aids to assist a team of terminal air traffic controllers in planning terminal traffic flow, merging arrivals, transitioning between runway configurations, and responding to changing weather or traffic conditions. The basis of TATCA automation is a computer-based traffic planning system that provides decision support to area supervisors and detailed assistance to radar controllers. This system will assist controllers in finding the most efficient means of satisfying operational metering and flow control constraints. A basic version of this planning aid will be available in the near term. Thereafter, the planning system will be supplemented by aids that assist controllers in fuel-efficient aircraft control and precise spacing. A final approach spacing aid will provide specific speed assignments or turn-to-final advisories that can be used by the final vector controller to reduce spacings on final approach without increasing the probability of missed approach. A descent advisor will determine descent profiles that permit aircraft to arrive at their bottom-of-descent point at a time that allows their smooth mergence into an efficient landing sequence (Project 3.5).

Opportunities exist to increase IFR capacity of multiple runway configurations based on the development of new ATC procedures and associated surveillance and navigation system improvements. Today, parallel runways can be used independently under IFR conditions only when centerlines are separated by 4300 feet or more. At narrower spacings, dependent approaches are used, dictating a radar-verified separation of at least 2 nautical miles between all aircraft on parallel approach courses. Independent operations on such runway pairs would provide about 33 percent more capacity. RE&D efforts are under way to achieve these separation reductions safely.

One promising concept is to use improved airport area surveillance sensors. Two types of technically and operationally viable precision sensors are being developed and tested that will provide for independent instrument approaches to multiple runway configurations (Project 6.3). Test programs are being conducted at the Raleigh-Durham and Memphis airports. A prototype high data rate radar beacon system with an electronically scanned, circular phased-array antenna has been installed and is undergoing testing at Raleigh-Durham. A Mode S radar beacon system with back-to-back antennas for high data rate has been installed at the Memphis airport, and data collection has started. Test data will be used to support the validation of a safety model and automatic blunder detection algorithms. Cost-benefit studies will be performed to determine the best system solution for candidate airports. Operational procedures and guidelines will be established based on test results. Final specifications for the sensors will be developed for follow-on production procurements planned for FY 1990 so as to achieve corresponding capacity benefits by the early 1990s.

ATC procedures for more fully utilizing the capacity of multiple runway configurations in instrument meteorological conditions are also under development. Parallel runways with centerline spacings as low as 3000 feet, converging and intersecting runways, and triple runway configurations are to be considered (Project 3.7).

Wake vortices are the single most limiting factor for IFR runway capacity. Wake-vortex research is being continued to further identify means to alleviate and avoid the hazards of wake vortices so that in-trail separations can be safely reduced. Research is being conducted on both conventional aircraft (Project 3.11) and rotorcraft (Project 3.12). Even for certain recent models of conventional aircraft, data must be collected to determine the strength of the wake vortices generated. Wake-vortex computer models for aircraft classification and hazard avoidance will be developed. Studies and measurements of rotorcraft wake vortices are being conducted to validate rotorcraft separation standards.

TABLE 4-3 -- PROJECTS SUPPORTING CAPACITY - TERMINAL AIRSPACE

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
2.7	Simulation Model Development and Validation (SIMMOD)	• Enhanced Simulation of Airways	Near-Mid
3.5	Terminal ATC Automation (TATCA)	• Dynamic Time-Based Planner	Mid
		• Automated Descent Advisor	Mid
		• Automated Final-Spacing Advisor	Mid
3.7	Airport Capacity Improvements	• Surveillance/Navigation System Requirements for Multiple IFR Approaches	Near
		• Procedures for IFR Approaches to Multiple Runway Configurations	Near
3.8	Rotorcraft/Power Lift Vehicles IFR Operations Evaluation	• Terminal Approach Procedures	Mid
		• Tiltrotor Airborne System Evaluation	Mid
3.9	Rotorcraft/Power Lift Vehicles ATC Procedures	• Procedural Changes	Near
		• Recommended Low-Altitude Route Standard	Near
3.11	Wake-Vortex Avoidance and Forecasting	• Models for Wake-Vortex Impacts on Aircraft Types	Near
		• Wake-Vortex Detection System	Mid
		• Wake-Vortex Forecasting Capability	Far
3.12	Rotorcraft Separation Standards	• Recommendations for Improved Separation Standards	Near
3.16	System Concept Definition	• Development and Evaluation of Synthetic Vision Conception	Near
4.5	Aeronautical Data-Link Communications Applications	• Communications Protocols and Software Integration	Near
		• Initial Mode S Services	Near
		• Air-Ground System Improvements	Mid
6.3	Landing Monitor for Closely Spaced and Converging Runways	• Production Procurement Specifications	Near
		• Operational Procedures and Guidelines	Near
6.5	Sustain Automated Radar Terminal Systems (ARTS)	• Define Required Near-Term Improvements	Near
10.4	Airport Capacity Task Force Studies	• Site-Specific Action Plans	Near

En Route Airspace Capacity

The objective in alleviating existing problems in en route airspace is to allow more aircraft to transition through a given volume of airspace, thereby enabling them to use trajectories of choice or at least get as close as possible to preferred routes. RE&D efforts in en route traffic management are directed toward providing automated assistance to the controller for deciding whether to grant a particular request for an aircraft trajectory.

The automated en route ATC (AERA) project will provide the en route controller with increased capability to manage traffic. AERA's "conflict probe" will warn controllers of potential separation violations to allow efficient resolution long before the expected encounter. Controllers will use that ability to check for conflicts, to reroute aircraft around storms, and to comply with specific pilot requests. The next phase of implementation will allow the computer to assist the controller in determining alternate routes when congestion forces a rerouting of aircraft (Project 3.3).

Development of the national airspace system performance analysis capability (NASPAC) is expected to facilitate en route capacity analysis and allow planners to study interactions between different parts of the airspace system.

Separation standards are being reviewed, as required, to ensure safety while reducing allowable horizontal, vertical, and longitudinal separations (Project 3.10). Tests will be conducted to provide quantitative guidance for separation minima permissible in the ATC system so as to allow the most effective use of new technologies as they are introduced.

TABLE 4-4 -- PROJECTS SUPPORTING CAPACITY - EN ROUTE AIRSPACE

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
3.3	Automated En Route ATC 3 (AERA 3)	• AERA 3 Systems Specifications	Mid
		• AERA 3 Preproduction Software	Mid
3.4	ATC Applications of Automatic Dependent Surveillance	• System Requirements - Display, Avionics, Links	Near
		• International Civil Aviation Organization System Standards	Near
3.10	Separation Standards	• Horizontal Separation Standards	Near
		• Recommendations for Reduced Vertical Separations	Near
3.15	Advanced Automation System (AAS)	• System Management and Direction	Near-Mid
5.3	Navigation Systems Development	• Federal Radionavigation Plan (FAA Part)	Near
		• GPS/LORAN C Integration Decisic ı	Mid
		• Final Decision, GPS Monitoring	Mid

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TABLE 4-4 (CONT.) – PROJECTS SUPPORTING CAPACITY - EN ROUTE AIRSPACE

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
6.2	Low-Altitude Surveillance	• Functional Design Specification	Mid
8.1	Satellite-Based Air-Ground Communications	• Summary Requirements Report	Mid
		• Support for International Standards	Mid
		• Support to Automatic Dependent Surveillance	Mid
8.2	Future Satellite C/N/S Systems Applications	• Summary of C/N/S Applications	Mid-Far
		• Technical and Economic Assessments	Mid-Far

Oceanic Airspace Capacity

Oceanic airspace capacity is currently constrained by the large aircraft standard separations that are required when surveillance and direct communications between ATC and the aircraft are unavailable. Significantly more aircraft can be given access to preferred oceanic routes when separation standards are reduced. For example, a reduction in longitudinal time separation from 20 to 5 minutes, along with a lateral separation distance reduction from 50 to 25 miles, would provide nearly an eight-fold increase in oceanic capacity. The predominant method for position determination of aircraft on oceanic routes is the use of inertial navigation systems. These can be cross-checked with OMEGA, LORAN, and very high frequency omnidirectional range (VOR) radionavigation systems where signals are available. By reliably providing for surveillance and direct communications, more routes can be established in oceanic airspace, and improved separation standards can be implemented.

The major effort toward establishing increased oceanic capacity involves the use of a concept called automatic dependent surveillance (ADS). With ADS, aircraft position data derived from onboard navigation systems and altimetry will be transmitted automatically to an ATC facility at regular intervals. The most promising near-term application of ADS uses a satellite-based air-ground communications data link. Activities necessary to support a reduction in oceanic airspace separation standards include requirements definition, operational concepts and system specification development, laboratory and flight tests, and an initial cost-benefit study. Analytical results will be validated through FAA-sponsored flight tests and the programs of other organizations and countries. The participation of air carriers in this activity will provide essential data (Project 3.4).

TABLE 4-5 -- PROJECTS SUPPORTING CAPACITY - OCEANIC AIRSPACE

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
3.4	ATC Applications of Automatic Dependent Surveillance (ADS)	• Technical Requirements - Display, Avionics, Links, Control System	Near
		• International Civil Aviation Organization System Standards	Near
8.1	Satellite-Based Air-Ground Communications	• Summary Requirements Report	Mid
		• Support for International Standards	Mid
		• Support to Automatic Dependent Surveillance	Mid
8.2	Future Satellite C/N/S Systems Applications	• Summary of C/N/S Applications	Mid-Far
		• Technical and Economic Assessments	Mid-Far

4.2.2 The Safety Mission

Over the past 10 years, the number of accidents involving scheduled airlines has remained relatively constant, even though air travel has grown markedly. As air traffic continues to grow, sustained RE&D efforts in all safety-related areas will be required. A breakdown of elements that contribute to the FAA's safety mission is shown in Figure 4-2.

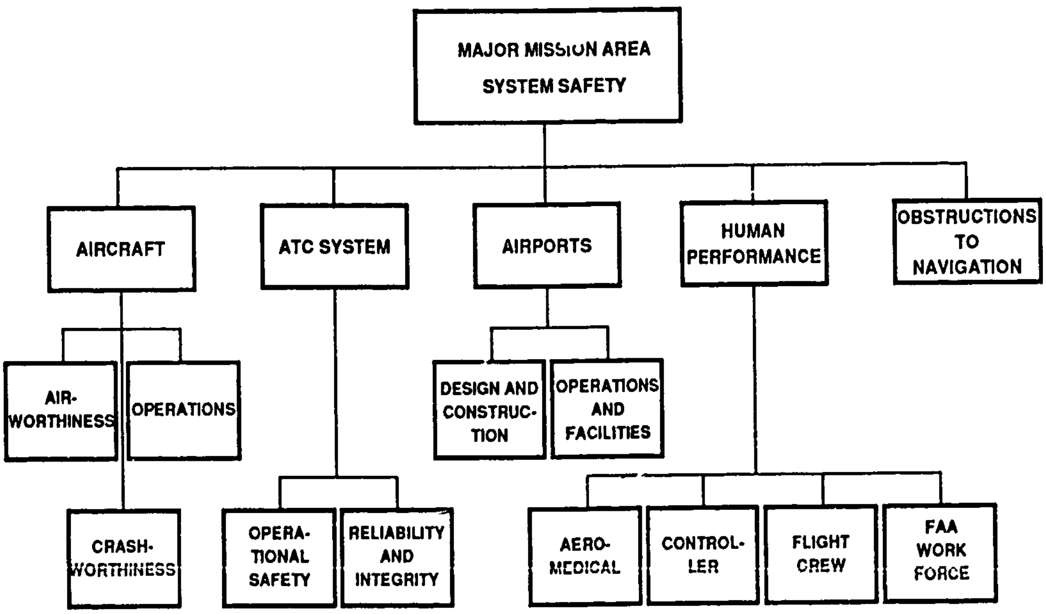

FIGURE 4-2 -- THE SAFETY MISSION AREA

As part of the new top-down management approach to RE&D, increased emphasis will be placed on nontechnological safety factors, specifically aviation safety procedures and human performance considerations. The importance of this increased emphasis is underscored by the past decade of safety experience, which indicates that over two-thirds of aviation-related fatalities involve human error.

The new RE&D approach subdivides the safety mission into five elements: aircraft, ATC system, airports, human performance, and obstructions to navigation. These mission elements form the basis for RE&D planning and the development of measures of air safety. To the extent these measures can be anticipated, safety metrics are presented along with a description of the near-, mid-, and far-term RE&D benefits.

To date, only limited analytical tools have been developed to support strategic management of aviation safety RE&D. In the near term, therefore, directions will be set on the basis of expert intuition and empirical findings such as those of the National Transportation Safety Board. Long-term safety RE&D goals are being developed which will enable FAA program managers to focus resources on specific objectives. While many safety metrics are needed to cover the entire spectrum of hazards and risks associated with the national aviation system, the ultimate goal remains the reduction of the probability of injury or loss of life associated with air transportation-related activities. Initial metrics for system safety are likely to be based on established databases and include measures such as incidents or accidents per thousand operations, near midair collisions per thousand miles flown, injuries per million passenger miles flown, and fatalities per million passenger miles flown.

Aircraft Safety

The aircraft safety mission represents an important component of the RE&D program. Projects associated with aircraft safety address many critical safety objectives, including aircraft airworthiness; crashworthiness; and operational safety concerns such as post-crash cabin survivability, avionics performance, and hazardous weather phenomena.

The ultimate indicator of aircraft safety is the resultant rate of aviation incidents and accidents involving aircraft components. Formal metrics, possibly reflecting safety measures such as aircraft component failures, the survivability of aviation accidents, fire or toxic smoke fatalities in survivable accidents, and unintended aircraft encounters with windshear or other severe weather phenomena, need to be developed and refined with due consideration of the numerous safety indicators already in use.

Aircraft Airworthiness

The airworthiness component of the RE&D Plan will be receiving greater emphasis than ever before. Growing concern about the safe useful life of aircraft will be addressed through increased efforts concerning the risks associated with aging aircraft (Project 11.8). While failure mechanisms and improved nondestructive inspection techniques will be the focus of most of the increased activity, all aspects of the aging aircraft issue will be analyzed to ensure that maintenance, inspections, and other precautions are sufficient to sustain or improve the safety of older aircraft within the fleet. The RE&D program is placing a special emphasis on aging aircraft beginning this year. Section 4.3.5 presents a more complete description of aging aircraft issues and RE&D responses.

In addition to the aging aircraft issue, the airworthiness RE&D component continues to address concerns relating to fuel and propulsion systems (Project 11.3) and flight safety and atmospheric hazards (Project 11.4). The potential for lightning to generate electromagnetic interference (EMI) with avionics and digital flight control systems will receive particular attention through a National Interagency Coordinating Group consisting of the FAA, NASA, DoD, National Oceanic and Atmospheric Administration (NOAA), and others.

In the near term, results are expected to include advanced knowledge concerning aviation fuels, as well as safety guidelines relating to lightning, aircraft icing, and EMI. Mid-term results should include avionics development, EMI safety guidelines, and findings from jet engine studies concerning bird ingestion and rotor burst protection alternatives. Far-term efforts are currently focused on advanced propulsion systems.

TABLE 4-6 -- PROJECTS SUPPORTING AIRCRAFT SAFETY - AIRWORTHINESS

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
2.13	FAA/NASA Cooperative Programs	• Technical Reports	Mid
11.3	Propulsion and Fuel Systems	• Fuel Study Reports	Near
		• Bird Ingestion Study Reports	Mid
		• Advanced Propulsion System	Far
		• Rotor Burst Protection Reports	Mid
11.4	Flight Safety/ Atmospheric Hazards	• Aircraft Icing Handbook	Near
		• Lightning and EMI Guidelines	Near
		• Avionics EMI Guidelines	Mid
11.8	Aging Aircraft	• Maintenance and Inspection Criteria	Near
		• Predictive Technology Training	Near
11.9	International Airworthiness Database	• System Requirements and Implementation Plan	Near
		• Prototype Feasibility Demonstration	Near
		• Evaluation Report	Near

Aircraft Crashworthiness

The crashworthiness component of the RE&D safety program addresses the obvious aircraft crashworthiness issues, as well as cabin safety concerns normally identified with crash and post-crash environments, particularly fire safety and passenger survivability. This segment of the RE&D program also addresses structural airworthiness issues relevant to crashworthiness (Project 11.2), yet distinct from concerns such as those associated with aging aircraft.

Cabin safety efforts are under way (Project 11.1) to develop fire safety technology and air safety regulations that will reduce fire-related fatalities. In the 5 years since 23 people aboard a DC9 died from exposure to fire and toxic fumes while the flight crew made a safe emergency landing, many fire safety features have been evaluated and made a part of required safety equipment. These include fire-blocking seat covers on planes with 30 or more seats, floor lighting that can assist passengers in finding exits in smoke-filled cabins, new cabin materials that produce far less toxic smoke when ignited, and improved smoke detectors and automatic fire extinguishers.

Near-term results from fire safety and occupant protection efforts are anticipated to include updated fire-resistant materials selection and test criteria, improved fire suppression and evacuation methods, and findings from an energy-absorption seat study and a cabin air-quality study. Mid-term results will provide increased knowledge concerning aircraft crashworthiness and structural airworthiness, in addition to furthering cabin safety through the development of new occupant protection design guidelines and completion of water survival and evacuation studies. For the far term, the crashworthiness, structural airworthiness, and occupant protection and survival characteristics of advanced aircraft will be identified, along with an assessment of the fire safety aspects of proposed hypersonic aircraft.

TABLE 4-7 – PROJECTS SUPPORTING AIRCRAFT SAFETY - CRASHWORTHINESS

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
11.1	Aircraft Systems Fire Safety	• Materials Selection/Test Criteria	Near
		• Suppression/Evacuation Methods	Near
		• Protection Design Guidelines	Mid
		• Hypersonic Transport Reports	Far
11.2	Aircraft Crashworthiness/ Structural Airworthiness	• Crashworthiness Study/Test Reports	Mid
		• Structural Airworthiness Reports	Mid
		• Advanced Structures Reports	Far
12.3	Protection and Survival	• Cabin Air-Quality Study	Near
		• Energy Absorption Seat Study	Near
		• Water Survival/Evacuation Studies	Mid
		• Advanced Aircraft Studies	Far

Aircraft Operations

RE&D projects in this area are designed to improve an aircraft's ability to avoid hazards or to operate safely under hazardous conditions. A significant component of this program is the traffic alert and collision avoidance system (TCAS), (Project 9.1). Designed to provide a safety backup to the ATC system, this program continues to receive the RE&D emphasis needed to complete development of TCAS III, demonstrate the readiness of TCAS II for deployment in commuter aircraft, and prepare all levels of TCAS (I, II, and III) for implementation.

Central to safe aircraft operations are efforts relating to onboard weather systems (Project 9.2). These closely relate to and complement agency efforts to improve ground-based weather resources and information transfer capabilities (Project 14.8). In addition to efforts to provide real-time weather information to the cockpit, projects in this area address rotorcraft/power lift vehicle safety issues such as advanced cockpit display and control systems (Project 11.6), needs for IFR operations at lower altitudes, and wake-vortex considerations.

Near-term results are expected to provide substantially improved weather protection. A system description will be completed for incorporating voice synthesis into existing low-level windshear avoidance systems. The effects of heavy rain on airborne windshear detectors will be investigated, along with the development of system requirements for airborne windshear detection sensors. Basic atmospheric data on icing conditions will be collected, and new icing forecasting techniques will be developed (Project 7.6). Near-term results are also expected to enhance the safety of rotorcraft operations through the development of separations standards based on criteria for wake-vortex avoidance (Project 3.12) and certification for advanced cockpit display and control systems. Results anticipated in the mid-term include the ability to produce improved icing forecasts, cockpit weather information and display requirements, and an operational evaluation of airborne IFR systems for tiltrotor aircraft operations (Project 3.8).

TABLE 4-8 -- PROJECTS SUPPORTING AIRCRAFT SAFETY - OPERATIONS

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
3.4	ATC Applications of Automatic Dependent Surveillance	• System Requirements - Display, Avionics, Control System	Near
		• Laboratory Flight Test	Near
3.8	Rotorcraft/Power Lift Vehicles IFR Operations Evaluation	• Revised Terminal Approach Procedure	Near
3.12	Rotorcraft Separation Standards	• Improved Separation Standards and Advisories	Near
7.4	LLWAS Voice Synthesis	• Direct Voice System Description	Near
7.6	Icing Forecasting Improvements	• Basic Atmospheric Data on Icing Conditions	Near
		• New Icing Forecasting Techniques	Near
		• Improved Icing Forecasts	Mid

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TABLE 4-8 (CONT.) -- PROJECTS SUPPORTING AIRCRAFT SAFETY - OPERATIONS

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
9.1	Traffic Alert and Collision Avoidance System (TCAS)	• Proximity Warning System Operational Tests	Near
		• Vertical Maneuver Advisory Commuter Demonstration	Near
		• Horizontal/Vertical Advisory Operational Tests	Near
		• Minimal Operational Performance Standards	Near
9.2	Airborne Windshear Detection and Avoidance	• System Requirements for Airborne Sensors	Near
		• Heavy Rain Effects Study	Near
		• Criteria for Alerting and Warning	Near
11.6	Rotorcraft/Power Lift Vehicles Display and Control Studies	• Cockpit Certification Criteria	Near
14.8	ATC Weather Information Transfer	• Weather Information and Display Requirements	Mid

ATC System Safety

The ATC system is relied upon to perform basic safety functions within the national aviation system, namely, to ensure that aircraft are separated from one another and that pilots are advised of potentially severe weather conditions. The safety functions of the ATC system are complex, involving a vast number of variables. The establishment of metrics for this area represents a significant undertaking that is not likely to be completed for some time. Interim metrics related to ATC system safety objectives include the number of near midair collisions in a given period of time, the number of aircraft intrusions into controlled airspace, and the rate of unintended and unpredicted aircraft encounters with severe weather conditions.

Several major improvements are under consideration regarding ATC system safety. Projects are split between those that support improvement to the operational safety of the ATC system and those that support improved system reliability or integrity.

ATC Operational Safety

The development of methods to provide improved weather data and information to pilots is central to this RE&D area. Continuing efforts to establish a weather processor (Project 7.5) that will provide pilots with near-real-time weather information derived from a variety of weather sensors and data sources, such as the national network of next generation weather radar (NEXRAD) systems currently under development (Project 7.1) and an enhanced low-level windshear alert system (LLWAS), (Project 7.3), combined with the development of an advanced ATC automation system (Project 3.15) and related data-link capabilities (Project 8.1), promise to greatly improve the overall safety performance of the ATC system. In addition, although intended for aircraft tracking rather than weather radar purposes, the potential for deriving useful weather information from the airport surveillance radar (ASR) system is receiving consideration.

Other important activities are under way to improve ATC surveillance capabilities in order to reduce the probability of aircraft collisions. A special surveillance system (Project 6.6) is being developed to address the problem of aircraft intruding into positive controlled airspace. Improvements to ATC surveillance and navigation systems (Projects 5.1 and 5.2) will provide pilots and air traffic controllers with the aircraft position information needed to implement advanced tactical control procedures, particularly during low-altitude operations. Advanced concepts, such as ADS, may also offer potential reductions in the risk of aircraft collision, especially in oceanic airspace, thereby supporting the safety mission in addition to capacity and efficiency.

In the near term, project results include the integration of LORAN C and the global positioning system (GPS) to establish a sole-means method of navigation that could eventually permit reduced reliance on the VOR/distance measuring equipment (DME) system, precision landing approach standards, procedures and guidelines to take advantage of new microwave landing system (MLS) capabilities, demonstration of a tactical radar to track airspace intruders, specifications for a weather processor and data link capable of providing real-time weather information to aircraft en route, and studies leading to the implementation of ATC applications of ADS. Mid-term results will include estimates of future ATC system requirements, assessments of emerging ATC technologies, development of a real-time weather information processor specification, and a review of satellite-based air-to-ground communications standards.

TABLE 4-9 -- PROJECTS SUPPORTING ATC SYSTEM SAFETY - OPERATIONAL

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
3.1	Advanced Traffic Management System (ATMS)	• Aircraft Situation Display Functional Specification	Near
		• Monitor-Alert Functional Specification	Near
		• Automated Demand Resolution Specification	Near
		• Strategy Evaluation Functional Specification	Near
		• Analysis and Technology Upgrade of Hardware	Mid
3.4	ATC Applications of Automatic Dependent Surveillance	• System Requirements for Detection, Navigation, and Control of Aircraft in Oceanic Airspace	Near
		• Operational Concept	Near
		• Study Reports - Dependent Surveillance Improvements	Near
		• Cost-Benefit Analysis	Near
		• International Civil Aviation Organization System Studies	Near
3.10	Separation Standards	• Feasibility of Reduced Horizontal Separation Standards (Oceanic Airspace)	Near
		• Simulation of Reduced Horizontal Separation Standards (Oceanic Airspace)	Near
		• International Coordination of Reduced Horizontal Separation Standards	Near
		• Evaluation of Reduced Vertical Separation Standards	Near
3.15	Advanced Automation System (AAS)	• Project Management and Direction	Mid
5.1	Improvements to Navigation Systems	• LORAN C/GPS Integration	Near
		• GPS Utilization	Near
5.2	Precision Approach and Landing	• MLS Autoland Systems Analysis	Near
		• Aircraft/ATC Integration Studies, Procedures	Near
5.3	Navigation Systems Development	• Navigational Aids Improvements	Near
		• Improved VOR Antennas	Near
6.1	Radar System Improvements	• Specification for Combined Tracker	Near
		• Specification for Modern Kit	Near
		• Test Plan/Report on Combined Performance of Mode S and ASR-9	Mid
		• New Certification Standards and Procedures	Mid
		• Mode S Transfer Implementation	Mid

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TABLE 4-9 (CONT.) -- PROJECTS SUPPORTING ATC SYSTEM SAFETY - OPERATIONAL

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
6.6	Special Surveillance System	• Demonstration Results Reports	Near
7.1	Next Generation Weather Radar (NEXRAD)	• NEXRAD Performance Reports	Near
		• Doppler-Based Algorithms	Near
7.3	Low-Level Windshear Alert System Enhancements	• Data Acquisition and Analysis	Near
		• Advanced System Development	Near
		• Enhanced Detection and ID Algorithm Development and Test	Near
		• Improved Maintenance Diagnostics	Near
		• LLWAS Operational Guidelines	Near
7.5	Central Weather Processor (CWP)	• Meteorological Weather Procedures, Interfaces	Near
		• Real-Time Processor Specification	Mid
8.1	Satellite-Based Air-Ground Communications	• Review of Communications Standards	Mid

ATC System Reliability and Integrity

Current and next generation ATC system enhancements are designed to very high reliability and integrity standards to ensure safety above all else. The present RE&D program does not contain projects oriented primarily toward system reliability and integrity, though it is anticipated that it will do so in future years.

TABLE 4-10 -- PROJECTS SUPPORTING ATC SYSTEM SAFETY - RELIABILITY AND INTEGRITY

PROJECT NO. AND TITLE	PRODUCTS	BENEFIT TERM
No current RE&D projects are aimed specifically at ATC system reliability and integrity.		

Airport Safety

The overall objective for airport safety is to develop airport systems to address hazards associated with airport design and construction and with operations and facilities in order to provide a timely, effective response in emergencies. Metrics useful in gauging airport safety-related RE&D efforts reflect incident and accident rates for airport operations and provide an indication of system safety performance. Examples of the latter would be measures of safety such as unpredicted windshear encounters in the vicinity of airports and average response time for fire or rescue services.

Airport Design and Construction

Many fundamental aspects of airport safety are linked to design and construction features. Lighting, visual guidance systems, wildlife control measures, and runway friction in wet or icy conditions exemplify fundamental characteristics that significantly impact airport safety. Related to these concerns is a need to develop appropriate fire and rescue technology and the techniques necessary to respond to airport incidents and accidents. The RE&D program addresses these vital concerns through an overall airport safety project (Project 10.2), as well as efforts to improve visual guidance (signs and lighting) for airport surface traffic (Project 10.3) and develop deceleration systems to safely arrest aircraft that overrun runways. Airport safety RE&D also will be directed at the particular needs of rotorcraft. Safety considerations for vertiport design and planning (Project 10.7) will address conventional rotorcraft as well as emerging tiltrotor aircraft. The safe integration of tiltrotor aircraft into the national aviation system has been designated as a special emphasis area for this year and is further discussed in Section 4.3.2 of this plan.

Near-term benefits include improved airport and vertiport design criteria; updated airport lighting standards; evaluations of runway friction measuring devices; studies of firefighting agents, equipment, and systems; further investigations into wildlife control measures; new snow and ice detection and measurement systems; and soft ground deceleration systems. Efforts offering mid- and far-term benefits are expected to assess future airport safety requirements and technologies, in addition to providing improvements in the areas of advanced visibility and aircraft deceleration systems.

TABLE 4-11 – PROJECTS SUPPORTING AIRPORT SAFETY - DESIGN AND CONSTRUCTION

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
6.3	Landing Monitor for Closely Spaced and Converging Runways	• Operational Procedures Demonstration	Near
10.2	Airport Safety	• Computer Analysis Programs and User Guides	Near
		• Specifications and Procedures Manual	Near
		• Lighting Standards	Near
		• Friction Measuring Devices	Near
		• Firefighting Agents, Equipment, and System Studies	Near
		• Wildlife Control	Near
		• Fuel Facilities Study	Near
		• Full-Scale Rescue and Firefighting Test	Near
		• Advanced Rescue and Firefightnig Test Fuel Facilities	Near-Mid
		• Visibility Tests	Near
		• Advanced Visibility Systems	Mid-Far
10.3	Airport Capacity and Delay	• Improved Airport Designs	Near-Mid
		• Snow and Ice Detection and Measurement	Near
		• Deceleration Systems (Soft Ground)	Near
		• Advanced Deceleration Systems	Near-Far
10.7	Heliport/Vertiport Design and Planning	• Data for Advisory Circular on Vertiport Planning Guidelines	Near

Airport Operational and Facility Safety

The primary operational safety concerns for airports involve wake vortex, windshear, and surface aircraft traffic hazards such as runway incursions. Aircraft wake-vortex capacity restraints are described in further detail above (in the section on terminal airspace capacity) and in Section 4.3.1.

Windshear is a dreaded atmospheric hazard, having been a causal factor in several major airline accidents. The RE&D program has addressed this threat since it was first identified several years ago. Efforts to date have included the development of LLWAS and advanced weather radar testbed prototypes for detecting windshear, and underlying research in support of recent airborne windshear detection equipage regulations. The terminal Doppler weather radar (TDWR) system (Project 7.2) also continues to address the windshear threat.

R··· cursions are a major and continuing surface traffic safety concern. The F ʒram addresses this and other concerns through efforts to develop surface tı ation techniques based on ASDE radar (Project 3.6), in addition to the re rt design and construction efforts discussed earlier in this section.

Ne . sults include improvements to aircraft wake-vortex classification tec ·rmit safe reductions in longitudinal aircraft separations, TDWR data acqu · vsis to determine the effectiveness of alternative windshear identil. liction techniques, and a functional description of a surface traffic conflict p ystem. Mid-term results include a report on the feasibility of wake-v asting systems and development of an automated surface traffic guidance . d based on ASDE radar technology.

TABLE 4-12 -- PROJECTS SUPPORTING AIRPORT SAFETY - OPERATIONAL AND FACILITY

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
3.6	Airport Surface Traffic Automation (ASTA)	• Runway Incursion Detectors	Near
		• Airport Surface Guidance System	Mid
		• Automated Ground Traffic Control	Mid
3.11	Wake-Vortex Avoidance and Forecasting	• Aircraft Classification	Near
		• Detection System Report	Mid
3.12	Rotorcraft Separation Standards	• Rotorcraft Wake-Vortex Hazard Model	Near
7.2	Terminal Doppler Weather Radar (TDWR)	• Data Acquisition and Analysis	Near
7.3	Low-Level Windshear Alert System Enhancements	• Advanced System Development	Near

Human Performance

Human performance capabilities are emerging as the critical impediment to achieving further improvements in aviation safety. Studies indicate that human error is a causal factor in over 65 percent of air carrier aviation accidents, and that this has not varied substantially during the past decade. While the future promises to bring more reliable aircraft and ATC system equipment, the past has shown that regardless of how reliable a system is, when it fails, humans are relied upon as the ultimate safety net. Human error, faulty decision making, and poor communications compound the problem. The role of alcohol, drugs, and other factors that alter human performance also give rise to concerns about the future safety of the national aviation system.

An improved understanding of human performance is crucial to achieving long-term improvements in aviation safety. Such efforts must cover all aspects of human involvement in the aviation system in a comprehensive manner. In addition to traditional aeromedical concerns, this new concept implies that the safety-critical roles and performance of FAA ATC system maintenance personnel and aviation safety inspectors must be considered, in addition to human performance issues regarding flight crews and air traffic controllers.

Although human performance is implicit to nearly every known measure of safety, metrics specific to human factors are few. The relationship of human performance to each measure of safety is an issue that warrants further investigation and quantification. Until more is known, traditional human performance-related safety metrics, such as pilot deviations and air traffic controller errors, will be relied upon.

The FAA's human performance RE&D program is receiving substantially increased emphasis. As such, it has been included as one of the special areas discussed in this plan (see Section 4.3.6). The program comprises aeromedical activities and controller, flight crew, and FAA work force performance research.

Aeromedical

The aeromedical portion of the human performance RE&D segment is currently focusing on the safety implications associated with drug use, the medical aspects of crashworthiness considerations, and the risks of radiation exposure during extended periods of high-altitude flight (Project 12.4). Near-term products are expected for each of these areas.

TABLE 4-13 -- PROJECTS SUPPORTING HUMAN PERFORMANCE - AEROMEDICAL

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
12.4	Aeromedical Program Support	• Drug Usage/Crashworthiness Criteria	Near
		• Revised Medical Standards and Procedures	Near
		• Radiation Handbook	Near

Controller Human Performance

Current trends toward increasing automation suggest that a systems approach to human performance must necessarily address human interaction with automated systems, as well as with other humans. A case in point is the highly automated ATC system being developed to aid controllers in managing air traffic while minimizing the potential for errors. Since humans are to be an integral part of this future system, it must tolerate impaired performance and be able to protect against or compensate for errors when they occur. Conversely, humans must be able to monitor these automated functions to ensure that unforeseen situations are handled safely.

Near-term RE&D benefits are expected to include improved training systems for air traffic controllers (Project 14.2) based on realistic ATC simulators that would reduce the need for extensive on-the-job training. ATC automation guidelines are to be developed in the mid-term, along with further studies of accident causal factors related to controller human performance (Project 14.1). The far term includes advanced studies of the interface between controllers and pilots in future systems.

TABLE 4-14 – PROJECTS SUPPORTING HUMAN PERFORMANCE - CONTROLLER

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
12.2	Human Performance Research	• Pilot/Controller Interface	Near
		• Pilot/Controller Error/Task Studies	Mid
		• Advanced System Studies	Far
14.1	Controller Human Factors	• ATC Automation Guidelines	Mid
		• Accident Causal Factors Analysis	Mid
14.2	AI Applications to Air Traffic Control	• Training Systems for En Route Controllers	Near
		• Training Systems for Terminal Controllers	Near
		• Simulation of Voice Entry	Near
		• Voice Recognition Equipment Specifications	Near
		• Prototype Procedures	Near
		• Report on Feasibility of Neural Nets to ATC	Near

Flight Crew Human Performance

Key elements under investigation are the human performance aspects of modern flight deck and flight crew operations, cockpit workload analyses, safety implications of advanced control and display technologies, and human performance considerations related to interactive voice and data-link communications.

Near-term results include an analysis of cockpit workloads for rotorcraft/power lift vehicles in low-altitude regimes (Project 9.3), tests of interactive-voice and voice-activated controls for cockpit instrumentation (Project 14.9), the development of flight crew performance criteria (Project 14.4), and studies of human performance causal factors in accidents and incidents (Project 14.3). Mid-term benefits will include flight deck certification guidelines (Project 14.10), an advisory circular on voice-activated cockpit instrumentation, standards for advanced rotorcraft simulators (Project 11.5), and a forecast of future RE&D requirements (Project 12.2).

TABLE 4-15 – PROJECTS SUPPORTING HUMAN PERFORMANCE - FLIGHT CREW

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
9.2	Airborne Windshear Detection and Avoidance	• Criteria for Alerting and Warning	Near
		• Cockpit Human Factors Study	Near
9.3	Rotorcraft/Power Lift Vehicles Obstruction Avoidance	• Low-Altitude Cockpit Workload	Near
		• Alternative Obstruction Avoidance System Studies	Mid
11.5	Rotorcraft Simulator Standards	• Standards for Visual/Motion Systems	Mid
		• Low-Visibility Approach Simulation Standards	Mid
11.6	Rotorcraft/Power Lift Vehicles Display and Control Studies	• Crew Information Transfer Reports	Near
12.2	Human Performance Research	• Pilot/Controller Interface	Near
		• Pilot/Controller Error/Task Studies	Mid
		• Advanced System Studies	Far
12.3	Protection and Survival	• Cabin Air-Quality Study	Near
14.3	Causal Factors in Accidents and Incidents	• Literature Review	Near
		• Error Classification	Near
		• Simulation Studies	Near
		• Accident/Incident Analysis	Near
14.4	Human Performance Assessment and Improvement	• Workload Assessment	Near
		• Crew Performance Criteria	Near
14.5	Information Transfer and Management	• Data Classification	Near
		• Data-Link User Requirements	Near
		• Flight Deck Information Requirments	Near
		• Impact of Data-Link on Flight Crew	Near
		• Enhanced Information Management Techniques	Near

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TABLE 4-15 (CONT.) -- PROJECTS SUPPORTING HUMAN PERFORMANCE - FLIGHT CREW

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
14.6	Aircraft Automation	• Flight Crew Workload Distribution	Near
		• Document Lessons Learned from Existing Automated Systems	Near
		• Intra-agency Reviews and Evaluation Procedures	Near
		• Advisory Circular on Operational Procedures	Near
14.7	Control and Display Technology	• Design Criteria for Charts and Displays	Near
		• Data-Link Display Options	Near
		• Functional Requirements, Data-Input Devices Voice Technology	Near-Far
14.8	ATC Weather Information Transfer	• Weather Information and Display Requirements	Mid
14.9	Interactive Voice Systems	• Simulation Design Report	Near
		• Flight Test Evaluaton Report	Near
		• Guidelines for Voice-Activated Controls	Near
		• Advisory Circular on Voice-Activated Controls	Near-Mid
14.10	Flight Deck Certification Criteria	• Certification Guidelines	Mid
14.11	Flight Crew Certification and Training	• Parts 121 and 135 Revisions	Near
		• Cockpit Resource Management Advisory Circular	Near
		• Cockpit Resource Management and Training Aids	Near
		• Simulation Fidelity	Near
		• Tasks, Knowledge, Skills, and Abilities (Capabilities)	Near
14.12	Human Factors and Regulatory Support	• Category III Procedures and Minima	Near
		• LORAN C/Pilot Interface	Near
		• Pilot Performance LORAN C	Near

FAA Work Force Human Performance

Activities are ongoing in the area of training and motivation (Project 12.1). Special emphasis is now placed on employing simulations to test human performance expectations. Such activities should aid in the development of the human resources needed to operate the national aviation system, as well as the design of future ATC system components and facilities. Work force optimization research is expected to result in near-term analysis of future maintenance technician tasks and develop human performance prediction techniques in the mid-term.

TABLE 4-16 -- PROJECTS SUPPORTING HUMAN PERFORMANCE - FAA WORK FORCE

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
12.1	Work Force Optimization Research	• Workload, Fatigue, and Stress Studies	Near-Far
		• Training Syllabus Development	Near
		• Employee Selection Tests	Mid-Far

Obstructions to Navigation

Obstructions to navigation are a safety concern for low-altitude flight operations for several reasons. These altitude regimes typically provide an obstacle-rich environment and often lack coverage of safety-critical communications, navigation, and surveillance services. While the problem is of great concern to rotorcraft and general aviation, it also is an impediment to implementing tiltrotor operations. An analysis of low-altitude cockpit workloads (Project 9.3) will provide near-term benefits in this area as well as further the human performance RE&D objectives mentioned above. Results from a study of alternative obstruction avoidance systems are expected in the mid-term.

TABLE 4-17 -- PROJECTS ADDRESSING OBSTRUCTIONS TO NAVIGATION

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
9.3	Rotorcraft/Power Lift Vehicles Obstruction Avoidance	• Low-Altitude Cockpit Workload	Near
		• Alternative Obstruction Avoidance Systems Study	Mid

4.2.3 The Security Mission

The FAA is the federal agency with primary responsibility for promoting the security of civil aviation. The increase in criminal activities targeted at aviation, the sophistication of techniques and technologies employed in these illegal activities, and the potentially deadly and costly consequences of aviation security violations have strengthened the importance of civil aviation security as a major mission of the FAA. Principal elements of this mission are shown in Figure 4-3.

The overall goal of RE&D projects which support civil aviation security is to maintain or enhance the present high level of protection for aircraft, airports, and the ATC system against existing criminal threats while preparing to interdict future threats through development of new security systems and procedures. Metrics that will be considered for evaluating and assessing RE&D projects include the number of missed weapons and explosives carried on board aircraft by passengers or in luggage, the number of unauthorized accesses to restricted airport areas, the number of unauthorized accesses to critical communications or computer systems, and the number of computer viruses or comparable violations of software integrity.

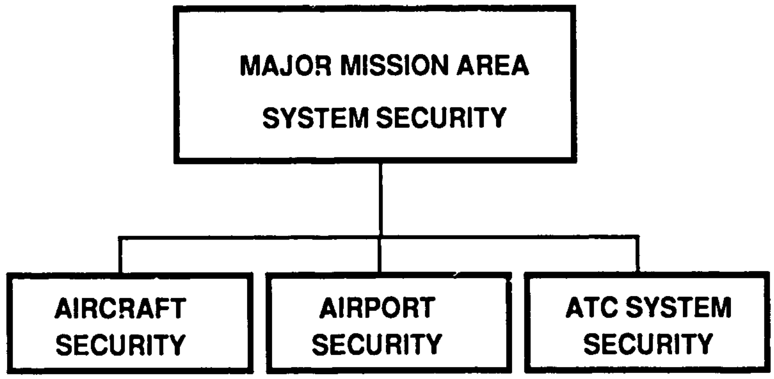

FIGURE 4-3 -- THE SECURITY MISSION AREA

Aircraft Security

The FAA is developing and testing technologies and procedures to rapidly and successfully screen passengers and luggage for concealed weapons and explosives. In the area of weapons detection (Project 13.2), current near-term efforts are primarily focused on feasibility studies of nonmetallic weapons detectors and development of a prototype advanced weapons detector and computer-aided weapons recognition system. With regard to explosives detection (Project 13.1), work is proceeding on the development of two basic types of detectors: one uses a "sniffer" to sense and identify the vapors from explosives, while the other produces electromagnetic energy or nuclear radiation which interacts with the explosive in bulk to sense and generate an identifiable radiation signature. Operational testing of prototype detectors based on these two technologies is under way at several airports. The agency also continues to solicit new ideas, identifying and evaluating those that appear to have practical applications for detecting weapons and explosives.

TABLE 4-18 -- PROJECTS SUPPORTING CIVIL AVIATION SECURITY - AIRCRAFT

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
13.1	Explosives Detection	• Operational Portal Prototype	Near
		• New Sensing Techniques	Mid
13.2	Weapons Detection	• Procurement Specifications	Near
13.4	Security Systems Integration	• Aircraft Design Guidelines	Mid-Far

Airport Security

RE&D is directed at development of an integrated security plan for all threat levels (Projects 13.3 and 13.4). This effort benefits from the findings of the Department of Transportation (DOT) Secretary's Task Force on Safety and Security. The first step in this process, which was largely completed by mid-1988, was to conduct studies defining present and future threats to airport security and assess the vulnerability of U.S. airports to these threats. Current efforts are focused on development of security systems and operational procedures for countering threats in an economically viable and responsive manner. Future activities will involve operational testing of systems and procedures to assess their effectiveness and their impact on airport activities and passenger flow.

TABLE 4-19 -- PROJECTS SUPPORTING CIVIL AVIATION SECURITY - AIRPORT

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
13.1	Explosives Detection	• Operational Portal Prototype	Near
		• New Sensing Techniques	Mid
13.2	Weapons Detection	• Procurement Specifications	Near
13.3	Airport Security	• Integrated Airport Security Specifications	Mid
13.4	Security Systems Integration	• Airport Design Guidelines	Mid-Far

ATC System Security

Unauthorized penetration of sensitive ATC computer and communications systems could result in major air traffic delays, with impacts valued at tens of millions of dollars, or jeopardize the safe separation of aircraft. Computer security considerations are therefore incorporated in the development of major ATC computer and communication systems, including the advanced automation system (AAS), (Project 3.15).

TABLE 4-20 -- PROJECTS SUPPORTING CIVIL AVIATION SECURITY - ATC SYSTEM

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
3.15	Advanced Automation System (AAS)	• Software Procurement Packages	Near

4.2.4 The Efficiency Mission

Within its role of promoting and encouraging civil aviation, the FAA bears important responsibilities concerning stewardship of resources and facilitation of a wide range of activities. Major elements of the efficiency mission are shown in Figure 4-4.

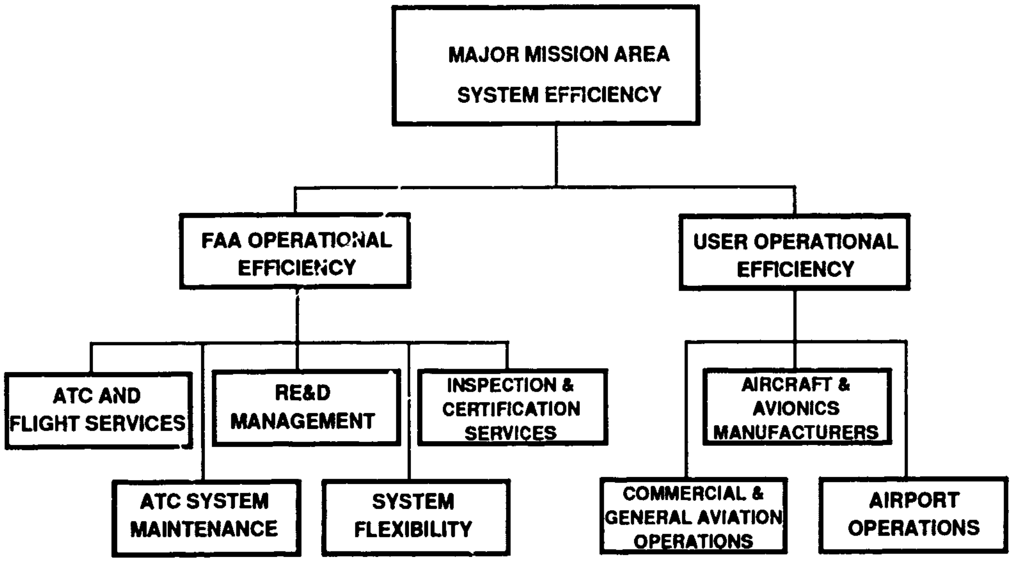

FIGURE 4-4 -- THE EFFICIENCY MISSION AREA

The RE&D program provides assistance in improving both government and private-sector efficiency and has the potential for producing significant economic benefits. The principal metrics, therefore, will be in terms of cost savings and return on investments. Efficiency objectives that have been identified include:

- User-preferred flight profi s -- Operator preferences as to routes, altitudes, and times of flight should be safely accommodated to the maximum extent possible.
- Lower operating costs -- Owners and operators of aircraft, airport operators, a wide range of related businesses, consumers, and the FAA itself stand to benefit from achievements in this area.
- Adaptability to changing needs -- The FAA requires the capability to respond to evolving national needs with minimal delays, and at the lowest cost in terms of new equipment or personnel and inconvenience to the public.
- System accessibility -- Users need and should expect ready access to government-provided services and the aviation system.
- Best use of FAA resources -- Development of improved approaches to the management and utilization of staff and facilities needs to be carried out, and RE&D provides an effective mechanism.
- Reduced regulatory burden for certification -- Certification of aircraft and airmen, a process involving the management of information, could be facilitated by

RE&D, with resultant benefits to applicants in terms of reductions in time and paperwork.

Projects for this mission area address both FAA and user efficiency.

Improved FAA Operational Efficiency

The FAA strives to meet all of its mission responsibilities in a cost-effective manner. The costs of running the nation's airways are largely paid by users who expect operations to be conducted efficiently. These operating expenses primarily reflect the cost of personnel and of the facilities and equipment needed to operate the national system of airways and airports. The 48,000 persons associated with operating the national aviation system include air traffic controllers, flight service specialists, maintenance technicians, safety inspectors, and certification specialists who perform operational duties, as well as the FAA management and support personnel who plan, budget, and manage the development of the system. The national aviation system contains over 20,000 major facilities, including terminal and en route air traffic control centers, radar equipment, computers and communications equipment, flight service stations and related equipment, and navigation and landing aids.

In addition to operating the ATC system around the clock, 365 days per year, the FAA is also a consumer of services and a major developer of (and customer for) computer, navigation, surveillance, and communications systems, many of which are highly technical and complex. FAA management recognizes the need and opportunity to improve the efficiency of its operations; functioning with high public visibility, the FAA seeks to improve both the quality of its services and the value rendered for each dollar spent. There are numerous ways in which this objective is served by the RE&D program. These include efforts to enhance air traffic control and flight services, ATC system maintenance, and RE&D resource management, as well as those to improve system flexibility and inspection and certification efficiency.

ATC and Flight Service Efficiency

The FAA's operation of the air traffic control system is a major undertaking. Projects supporting this aspect of the efficiency major mission area are primarily directed at maximizing the productivity of personnel resources through greater levels of automation and system planning.

System planning efforts are expected to provide an overall framework to facilitate and guide the development of future ATC and flight service systems, and ensure the most efficient use of resources. Efforts to develop fundamental new ideas and methods for air traffic control and to identify advanced technologies needed to meet future requirements will continue. These include the identification of the near-term enhancements necessary to assure the future safety, productivity, and efficiency of aviation operations and, in the mid- to far-term, the development of functional operational concepts and requirements validation studies (Project 2.1). The systematic planning of a national simulation facility to validate future roles proposed for elements of the aviation system is under way. This facility will provide the capability to test full systems which include pilot and controller interfaces and ground and airborne automation. The planning for this laboratory has been initiated (Project 3.16).

Higher levels of automation are expected to significantly increase the productivity of air traffic control personnel in managing and controlling the use of airspace, thereby improving the flow of aircraft. Several RE&D projects support this objective. Development of an advanced traffic management system (ATMS) -- including the aircraft situation display (ASD), monitor-alert function, and automated demand resolution capability -- will allow traffic managers to efficiently allocate demand to available system capacity (Project 3.1). Functional requirements for a dynamic special-use airspace management system will be developed in the near term, leading to increased flexibility in the allocation and use of this airspace by military and civilian users (Project 3.2). To increase the efficiency of terminal airspace operations, a terminal ATC automation aid is being developed (Project 3.5).

RE&D efforts are under way to enhance the training of air traffic controllers. A new project will be formalized in FY 1990, extending exploratory FY 1989 efforts to determine the feasibility of using expert system techniques to provide an improved controller training aid. The potential for reducing required controller training time or maintaining or improving training effectiveness will be ascertained (Project 14.2).

TABLE 4-21 -- PROJECTS SUPPORTING IMPROVED FAA OPERATIONAL EFFICIENCY - ATC AND FLIGHT SERVICES

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
2.1	NAS System Requirements	• Operational Requirements and Maintenance	Mid-Far
		• Functional Operational Concepts	Mid-Far
		• Requirements Validation Studies	Mid-Far
2.8	National Airspace System Performance Analysis Capability (NASPAC)	• Models Validation	Mid
		• Models Enhancement	Mid
		• Models Application	Mid
3.1	Advanced Traffic Management System (ATMS)	• Analysis and Technology Update of Alert System	Near
		• Operational Improvement of Monitor Alert on Enhanced Traffic Management System (ETMS)	Near
		• Operational Implementation of Automated Demand Resolution on ETMS	Near
		• Operational Implementation of Strategy Evaluation on ETMS	Near
		• Operational Implementation of Automated Message Distribution	Near
		• Upgrade System Hardware	Mid

Continued on Next Page

TABLE 4-21 (CONT.) – PROJECTS SUPPORTING IMPROVED FAA OPERATIONAL EFFICIENCY - ATC AND FLIGHT SERVICES

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
3.2	Dynamic Special-Use Airspace Management	• ATC Functional Requirements	Near
		• Joint Operations Package	Mid
3.3	Automated En Route ATC 3 (AERA 3)	• AERA 3 System Specifications	Mid
		• AERA 3 Preproduction Software	Mid
3.5	Terminal ATC Automation (TATCA)	• Concept Definition and Demonstration	Mid
		• TATCA F&E Specifications	Mid
3.15	Advanced Automation System (AAS)	• System Management and Direction	Near-Mid
3.16	System Concept Definition	• Integrated ATC Automation Concept	Mid
		• Advanced Concepts Laboratory	Far
4.1	Future Communications Requirements and Architecture	• Digital Interfacility Network Architecture	Near
		• Integrate Voice/Data Interfacility Communications	Near
		• Digital Communications Protocols	Near
		• Digital Microwave System	Mid
4.2	Network Management and Control Equipment (NMCE)	• NMCE Specification	Mid
4.3	Voice Switching and Control System Development (VSCS)	• System Management	Near
4.4	National Airspace Data Interchange Network (NADIN)	• Phase II Expansion Requirements	Near
		• NADIN II Design Verification	Near
4.5	Aeronautical Data-Link Communications Applications	• Data-Link Standards	Near
		• Initial Mode S Services	Near
		• Air-Ground System Improvements	Mid
5.1	Improvements to Navigation Systems	• Navigation System Engineering	Near
6.2	Low-Altitude Surveillance	• Cost-Benefit Analysis	Mid
		• Functional Design Specifications	Mid
6.4	Surface Traffic Surveillance	• System Design	Mid
		• Testbed Demonstration	Mid
		• Flight Testing	Mid
7.2	Terminal Doppler Weather Radar (TDWR)	• Windshear Detection System	Near

Continued on Next Page

TABLE 4-21 (CONT.) -- PROJECTS SUPPORTING IMPROVED FAA OPERATIONAL EFFICIENCY - ATC AND FLIGHT SERVICES

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
8.1	Satellite-Based Air-Ground Communications	• Summary Requirements Report	Mid
		• Cost-Benefit Study	Mid
8.2	Future Satellite C/N/S Systems Applications	• Summary of C/N/S Applications	Mid-Far
		• Technical/Economic Assessments	Mid-Far
11.9	International Airworthiness Database	• System Operation	Near
12.1	Work Force Optimization Research	• Workload, Fatigue, and Stress Studies	Near-Far
		• Training Syllabus Development	Near
		• Employee Selection Tests	Mid-Far
14.2	AI Applications to Air Traffic Control	• Training System for En Route Controllers	Near
		• Training System for Terminal Controllers	Near
		• Simulation of Voice Entry	Near
		• Voice Recognition Equipment Specifications	Near
		• Prototype Procedures	Near
		• Report on Feasibility of Neural Nets	Near

ATC System Maintenance Efficiency

Given the current transition to a new generation of ATC system equipment, much of which is based on highly reliable technologies, coupled with ongoing changes in the maintenance work force, it is important to employ applicable RE&D measures to ensure current and future efficiencies in the application of personnel. The FAA's electronic technician work force is critical to ATC system maintenance. Work force optimization research includes near-term development of an airway facilities technician job task analysis (Project 12.1).

TABLE 4-22 -- PROJECTS SUPPORTING IMPROVED FAA OPERATIONAL EFFICIENCY - ATC SYSTEM MAINTENANCE

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
2.1	NAS System Requirements	• System Engineering Management	Mid-Far
		• Operational Requirements and Maintenance	Mid-Far
12.1	Work Force Optimization	• Technician Job Task Analysis	Near

Efficient Management of RE&D Resources

The RE&D program includes support for a variety of tasks related to management of RE&D resources. Products of these tasks range from the annual RE&D budget to milestone reports needed for management oversight, and include the annual FAA RE&D Plan (Projects 2.2, 2.3, 2.5). A system engineering management project provides project management tools and related services (Project 2.4). The RE&D program is also seeking to improve the use of resources by strengthening research and development alliances with universities, small businesses, and the Transportation Research Board (Projects 2.10, 2.11, 2.12).

TABLE 4-23 -- PROJECTS SUPPORTING IMPROVED FAA OPERATIONAL EFFICIENCY - RE&D MANAGEMENT

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
2.1	NAS System Requirements	• Operational Requirements and Maintenance	Mid-Far
		• Functional Operational Concepts	Mid-Far
		• Requirements Validation Studies	Mid-Far
2.2	Research, Engineering, and Development Plan	• FAA Annual RE&D Plan	Near-Mid-Far
2.3	Management and Control Process	• Annual RE&D Budget	Near-Mid-Far
2.4	System Engineering Management	• Project Management Tools and Services	Mid
2.5	ADM Program Support/ Management Initiatives	• Management Information System for Advanced Design and Management Control	Near
		• Project Resumes and Reports	Near
		• Milestone Reports	Near
		• Management Information System for NAS Development	Near
2.6	Future System Definition	• RE&D Recommendations	Mid-Far
2.9	Airspace System Models	• Model Applications	Mid-Far
2.10	Joint University Air Transportation Technology Program	• Quarterly Conferences	Near-Mid
		• Annual Reports	Mid
2.11	Transportation Research Board	• Forecast Methodology Workshops	Mid
		• Strategic Plan Inputs	Far
2.12	Small Business Innovation Research Program	• Research Reports	Near

Efficiency through System Flexibility

The current ATC system is relatively inflexible with respect to fluctuations in demand, both in terms of traffic levels and air traffic services. Changes in air traffic demand patterns can cause costly delays or make the existing allocation of air traffic controllers less efficient until the ATC system can be reconfigured and controllers reassigned or retrained. Such changes [illegible] occur from week to week or season to season, or may reflect gradual trends continuing many years into the future. The current ATC system, designed to serve regulated, point-to-point air traffic, has evidenced its limited capability to accommodate the rapid changes associated with the hub-and-spoke operations that typify today's airline industry. It also has limited the ability of the agency to efficiently utilize controllers, since air traffic sector boundaries cannot be modified easily in response to changing traffic demands. Hub-and-spoke operations produce "waves" of air traffic that present some controllers with maximum traffic levels while others have relatively little traffic to control when airplanes converge around major hubs.

The RE&D program includes several projects that will provide the FAA with greater flexibility to respond to future traffic demands. RE&D supports the development of NAS F&E Plan components which will enable the ATC system to be dynamically reconfigured in response to changing traffic demands. Such systems will incorporate a unified architecture capable of supporting near-term improvements and long-term growth, without disrupting ATC services (Project 2.9).

In another project, evolving technology is being evaluated to determine whether it can be used to help the FAA communications network respond flexibly to changing and growing needs. To achieve this objective, research is under way to evaluate the costs and impact of a digital microwave system and digital radio control equipment. If feasible, these technologies will be implemented in the mid-1990s (Project 4.1). Technical and economic assessments of future satellite applications combining communications with navigation and surveillance capabilities are being conducted. It is believed that such satellite-based systems will be the logical followup to current ground-based systems and will provide the flexibility needed to respond to future demands.

TABLE 4-24 -- PROJECTS SUPPORTING IMPROVED FAA OPERATIONAL EFFICIENCY - SYSTEM FLEXIBILITY

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
2.9	Airspace System Models	• Models Application	Mid
3.2	Dynamic Special-Use Airspace Management	• Interagency Procedures	Near
		• Database and Communications Requirements	Near
		• Joint Operations Package	Mid
4.1	Future Communications Requirements and Architecture	• Intrafacility Network Architecture	Near
		• Interfacility Voice/Data Communications Architecture	Near
		• Digital Microwave System	Mid
4.2	Network Management and Control Equipment (NMCE)	• NMCE Specification	Mid
8.2	Future Satellite C/N/S Applications	• Technical and Economic Assessments	Mid

Inspection and Certification Service Efficiency

The RE&D program includes projects intended to enhance the FAA's aircraft and personnel inspection and certification services. Work force optimization research will yield improvement in the agency's ability to select, train, and certify controllers and maintenance technicians (Project 12.1). Benefits of this effort will include a reduction in training time and costs and the selection of better controllers. A new certification program will facilitate introduction of the tiltrotor aircraft (Project 11.7). Emphasis will be on human performance, the transition and approach phases of flight, and tiltrotor integration into the national aviation system.

TABLE 4-25 -- PROJECTS SUPPORTING IMPROVED FAA OPERATIONAL EFFICIENCY - INSPECTION AND CERTIFICATION SERVICES

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
11.7	Tiltrotor Certification Support	• Reports Documenting Tests of Tiltrotor Systems	Near
		• Technical Certification Basis	Near
12.1	Work Force Optimization Research	• Safety Inspector Selection Tests	Near-Mid

Improved Efficiency in User Operations

Helping to reduce the operating costs of users is a longstanding goal of the FAA. Three aspects of user operational efficiency are supported by the RE&D program: commercial and general aviation operations, FAA-manufacturer interface, and airport operations.

Commercial and General Aviation Operations

The RE&D program seeks to assist in enhancing the efficiency of commercial and general aviation operations by providing for flexible and preferred routings, increasing accessibility to services, reducing delays, and modernizing the certification process.

For flexible and preferred routings, means to accommodate user desires will be provided through AERA. A system concept for operation, system specifications, and plans for implementation of AERA are being developed (Project 3.3), as well as improved routing options for oceanic areas (Project 3.13). This effort will result in system specifications and flight tests; it envisions implementation ultimately in domestic areas as well as oceanic areas. Studies of future satellite communications, navigation, and surveillance (C/N/S) applications (Project 8.2) offer the prospect of greatly increased user access to important ATC services. Reduction of delays is expected from weather-related RE&D activity. Once implemented, the central weather processor (Project 7.5) will make weather information more readily available to pilots and other users.

TABLE 4-26 -- PROJECTS SUPPORTING IMPROVED EFFICIENCY IN USER OPERATIONS - COMMERCIAL AND GENERAL AVIATION

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
2.8	National Airspace System Performance Analysis Capability (NASPAC)	• Models Validation	Near
		• Models Enhancement	Mid
		• Models Application	Mid
3.1	Advanced Traffic Management System (ATMS)	• Functional Specifications for Aircraft Situation Display, Monitor Alert, Automated Demand Resolution, Strategy Evaluation, Automated Message Distribution	Near
3.2	Dynamic Special - Use Airspace Management	• ATC Functional Requirements	Near
		• Joint Operations Package	Mid
3.3	Automated En Route ATC 3 (AERA 3)	• AERA 3 System Specifications	Mid
		• AERA 3 Preproduction Software	Mid
3.5	Terminal ATC Automation (TATCA)	• Dynamic Time-Based Planner	Mid
		• TATCA F&E Specifications	Mid

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TABLE 4-26 (CONT.) -- PROJECTS SUPPORTING IMPROVED EFFICIENCY IN USER OPERATIONS - COMMERCIAL AND GENERAL AVIATION

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
3.13	Fuel Optimization: Dynamic Ocean Track System (DOTS)	• Prototype of Ocean Track System Specification	Near
		• Fuel-Efficient Trajectories	Near
		• Flight Test of Prototype in Central Pacific	Near
		• Ocean Implementation	Near
		• CONUS Implementation	Mid
3.14	Fuel Shortage Contingency Planning	• National Oil Shortage Analysis Model	Near
7.1	Next Generation Weather Radar (NEXRAD)	• Doppler-Based Algorithms	Near
7.5	Central Weather Processor (CWP)	• Real-Time Processor Specification	Mid
8.2	Future Satellite C/N/S Systems Applications	• Technical and Economic Assessment	Mid
14.9	Interactive Voice Systems	• Guidelines for Voice-Activated Controls	Near
		• Standards for Voice-Activated Cockpit Systems	Mid

FAA - Manufacturer Interface

The RE&D program has the potential of reducing paperwork, improving communications, and generally speeding up processes concerned with federal inspection and certification. Tiltrotor certification support (Project 11.7), already cited, promises to accelerate and simplify the introduction of this new type of aircraft.

TABLE 4-27 -- PROJECTS SUPPORTING IMPROVED EFFICIENCY IN USER OPERATIONS - AIRCRAFT AND AVIONICS MANUFACTURERS

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
11.7	Tiltrotor Certification Support	• Technical Certification Basis	Near

Airport Operational Efficiency

Continued assistance to owners and operators of airports is provided under the FY 1989 RE&D program to ensure operational efficiencies. Subjects of this work include airport capacity improvement, terminal/landside traffic management, planning guidelines for vertiports, and runway construction technology. The system capacity and airports program seeks improvements through projects for reduced runway occupancy time (Project 10.3) and airport capacity development (Project 3.7). It is believed that further improvements can be made in both runway design and the operational procedures that would permit IFR operation with high-efficiency configurations of parallel or converging runw , thus facilitating aircraft movements.

Vertiports represent a significant option for the future, considering existing problems of airport saturation, the availability of helicopters, and the imminent realization of the tiltrotor. Under the project for planning guidelines for vertiports (Project 10.7), the RE&D program anticipates assistance to vertiport developers. Its near-term products are scheduled to include a design guide and vertiport lighting design criteria.

As a focus of its ongoing efforts to assist airport owners and operators with current guidelines relating to runway construction, Project 10.1 addresses pavement strength, durability, and repair. Products of this effort will include computer programs and user guides; design, construction, and maintenance guidelines; and materials research reports to aid in extending runway availability by reducing maintenance downtime.

TABLE 4-28 -- PROJECTS SUPPORTING IMPROVED EFFICIENCY IN USER OPERATIONS - AIRPORTS

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
3.7	Airport Capacity Improvements	• Multiple Runway IFR Procedures	Near
		• Multiple IFR F&E Standards	Mid
10.1	Pavement Strength, Durability, and Repair	• Technical Reports and Procedures	Near
		• Computer Programs and User Guides	Mid
		• Test Methods	Mid
		• Design, Construction, Maintenance Guidelines	Mid
		• Advanced Aircraft and Materials Research	Far
10.3	Airport Capacity and Delay	• Reduced Runway Occupancy Time	Near
		• Passenger Flow Simulation Model	Mid
		• Aircraft/Airport Compatibility Studies	Mid
		• Total Airport Systems Model	Far
10.4	Airport Capacity Task Force Studies	• Action Plans for Capacity Improvements	Near

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TABLE 4-28 (CONT.) -- PROJECTS SUPPORTING IMPROVED EFFICIENCY IN USER OPERATIONS - AIRPORTS

PROJECT NO. AND TITLE		PRODUCTS	BENEFIT TERM
10.5	Airport Capacity Enhancement Planning	• Airport Capacity Enhancement Plan	Mid
10.6	Terminal/Landside Traffic Model	• Terminal Design Aid Software	Mid
10.7	Heliport/Vertiport Design and Planning	• Data for Advisory Circular on Vertiport Planning Guidelines	Near

4.3 RE&D Response to Impact 88 and Other Current Issues

First articulated in the summer of 1987, Impact 88 is the FAA's pledge to accelerate and redouble agency efforts to safely steer civil aviation "through turbulent skies." It highlights areas where the FAA is either accelerating existing initiatives, developing new ones, or changing directions to become more responsive to the demands of a deregulated aviation marketplace, focusing on eight principal areas: (1) aircrew performance, (2) airline accountability, (3) airport development, (4) airspace capacity, (5) advanced technology, (6) aviation awareness, (7) air transportation security, and (8) agency effectiveness.

The FAA RE&D program is a vital part of the comprehensive efforts outlined by Impact 88. This section presents several areas of RE&D emphasis which directly support the Impact 88 initiatives as well as the concerns expressed by Congress and the aviation community. Twelve special areas are highlighted:

- Airports
- Tiltrotor
- Vision Enhancement for Pilots
- Satellite Applications
- Aging Aircraft
- Human Performance
- Collision Avoidance
- Avoiding Atmospheric Hazards
- Civil Aviation Security
- Operations Research Applications
- Airspace Management and Traffic Flow Control
- Planning for the Future

4.3.1 Airports

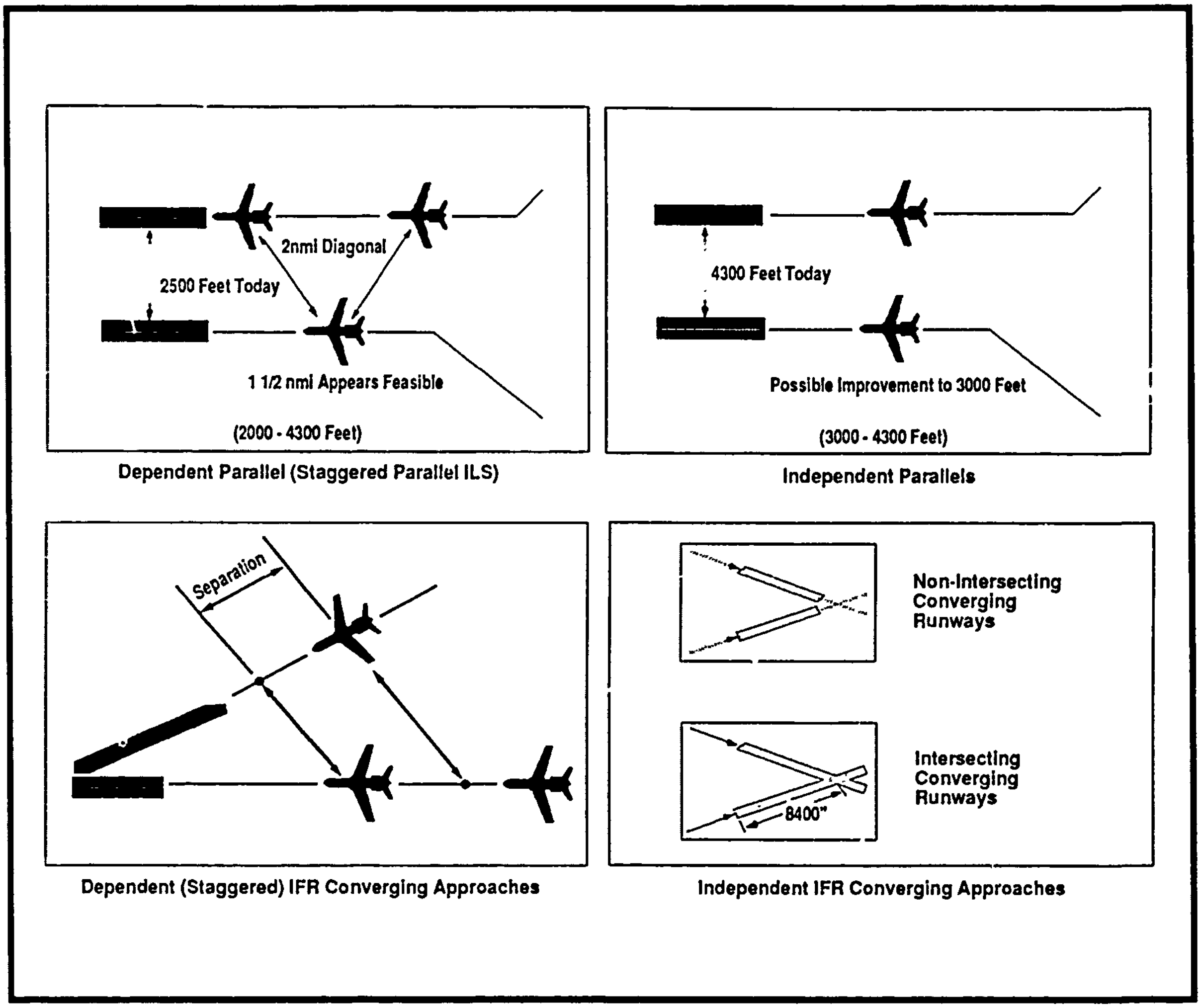
While airline deregulation is credited with providing consumer benefits of $10 billion per year, congestion and delay, undesirable side effects of this success, are costing the nation an estimated $3 to $5 billion a year in lost time alone. The FAA acknowledges that congestion has neither a single cause nor simple solutions. Currently, emphasis is directed at airport capacity, which overwhelmingly is perceived as the most severe problem. The goal for RE&D in this area is to accommodate current and projected levels of demand with minimum delays, without compromising safety or the environment. Three strategic components of this program are: (1) the evaluation, development, and validation of promising concepts for safely increasing airport and terminal airspace capacity, especially during periods of reduced visibility; (2) the development and application of analytical models and simulations to anticipate the future occurrence of congestion and delay, improve understanding of capacity limitations, and evaluate potential remedies; and (3) the investigation and development of technologies and methods for safely mitigating or overcoming capacity constraints imposed by noise or wake-vortex restrictions.

Airport and Terminal Airspace Capacity

In 1982, the FAA convened the Industry Task Force on Airport Capacity. Since then, this group has identified priority airport capacity RE&D opportunities on a continuing basis. Several major initiatives now support airport capacity objectives established by the task force. These RE&D initiatives include independent approaches to closely spaced parallel or converging runways during IFR conditions, IFR procedures for triple parallel runway operation, terminal area traffic control automation aids, surface traffic surveillance and automation, high-capacity MLS approach procedures, high-capacity runways and taxiways, pavement designs to reduce runway reconstruction and repair, and continued airport capacity task force planning activities and capacity enhancement studies. Other capacity-related efforts have also resulted from the group's efforts. These include efforts to improve terminal area traffic flow analyses and models and to reduce the adverse operational impact of wake vortices. Favorable results to date are being accelerated in response to an FY 1989 congressional funding increase.

Wake Vortex of Helicopter

The greatest potential for relieving congestion in the near term involves more extensive implementation of high-capacity multiple runway operations at high-traffic locations. In particular, independent approaches to closely spaced or parallel runways are a highly promising means of increasing airport capacity. Typically, these runways are less than 4300 feet apart. Capacity of such runways is currently limited in adverse weather by the limitations of existing airport surveillance systems. To ensure safe separations under IFR conditions, aircraft approaching one runway must be closely coordinated with aircraft approaching the other. The result is a limitation on capacity.



High-Capacity Multiple Runway Operation Strategies

Past research and analysis have determined that restrictions on independent approaches to closely spaced or parallel runways could be reduced, without compromising safety, if controllers could obtain more frequent and accurate surveillance information. Two technical approaches to achieving a precision terminal sensor are being pursued vigorously. The air traffic control radar beacon system monopulse processing system is being tested at Memphis, Tennessee. The precision runway monitor system -- a high data rate, phased-array secondary surveillance radar based on technology developed for TCAS

-- is being evaluated at Raleigh-Durham, North Carolina. Triple parallel IFR approach procedures and system operations currently being developed will be demonstrated in FY 1991, when a third parallel runway is operational at an airport such as Dallas-Ft. Worth.

The operational aspects of multiple runway operating configurations at major airports are being addressed through efforts that complement the Memphis, Raleigh-Durham, and Dallas-Ft. Worth investigations. During FY 1989, data will be collected at O'Hare Chicago to ascertain actual aircraft performance during simultaneous independent instrument approaches to parallel runways and to provide the basis for risk assessment. To achieve the fullest benefit of multiple runways, approach procedures which take advantage of MLS capabilities are being developed and validated in a related effort. Looking to the future, efforts are under way to develop a base of knowledge regarding expert systems and automated tools to help controllers use terminal airspace and runways at peak efficiencies based on prevailing conditions. These TATCA efforts include developing a new controller display for dependent converging approaches and a dynamic traffic planning and controller advisory system which can help controllers minimize inefficiencies in traffic sequencing, balance traffic loadings between feeder fixes and runways, space aircraft efficiently on final approach, and determine the optimum speed and descent profiles for approaching traffic. Initial implementation of this display is planned for St. Louis and Boston during 1990.

Another limitation on airport capacity is the delay which occurs on the airport surface. Alternative uses for the new ASDE radar, now being deployed at major airports, are being investigated to determine this equipment's potential for reducing runway incursions and enhancing surface traffic flow. A transportable ASDE/Mode S data-link testbed will be designed this year, with the ultimate goal of field validating and demonstrating the performance and value of real-time ASDE aircraft tracking on airport surfaces during FY 1995.

Runway design and management are other fundamental elements of airport capacity. The RE&D program includes a continuing evaluation of alternative runway and taxiway designs (including high-speed features) with the potential to reduce runway occupancy time or decrease taxiing time; this evaluation will be completed in FY 1992. Continuing efforts also seek to improve airport pavements to achieve greater durability and performance characteristics. In addition, work is proceeding to improve standards for taxiway signing and lighting to facilitate surface traffic movements during periods of limited visibility.

System Modeling and Capacity Planning

Rapid growth in air traffic following deregulation exposed several aviation system capacity-planning deficiencies. Former planning methods which focused on individual system elements within a regulated operational environment were insufficient to cope with the rapidly growing and changing traffic patterns resulting from deregulation. The inability to correctly predict current traffic demand has made the FAA fully aware of the need for improved planning methods that will better enable it to identify future capacity deficiencies well in advance so that solutions can be developed in a timely manner. The RE&D program has responded to the well-recognized need for comprehensive, long-range systems planning efforts which take advantage of modern computer modeling and simulation techniques to rapidly evaluate alternatives in advance of development.

In FY 1988, the NASPAC project was initiated to aid in identifying performance-limiting factors on a systemwide basis. A prototype NASPAC model will be completed and demonstrated in FY 1989, with full validation by the end of FY 1990. Beginning in FY 1990, additional airspace system models will be developed to analyze the systemwide impact of airline fleet and route expansions and weather. The RE&D program includes user enhancements to SIMMOD, an airport and airway simulation model which already has been used to identify and develop revised airspace, air routes, and aircraft control procedures that have reduced delays in heavily traveled East and West Coast corridors. The program also furthers the highly successful efforts of Airport Capacity Enhancement Task Forces in which airport operators, airlines, and industry groups work together with the FAA to develop site-specific alternatives for improving airport capacity which can then be evaluated using computer simulations. The 1989 version of the Airport Capacity Enhancement Plan will be produced to document the results of these ongoing capacity-planning efforts.

Noise and Wake Vortex

Noise and the wake-vortex phenomenon are two very significant impediments to accommodating current and forecasted air traffic demand.

The aircraft noise reduction and control element of the RE&D program seeks to improve understanding of noise phenomena, advance the state of the art regarding noise-reduction technology, and develop highly effective and safe noise-abatement operating procedures. Past emphasis on controlling noise at its source (aircraft) is being expanded to include airport land-use compatibility planning and economic incentive options for minimizing noise impacts. Noise implications of emerging aircraft technology, such as a hypersonic "Orient Express," unducted fan engines, and tiltrotors, will be analyzed. The refinement of the integrated noise model will also continue, along with cooperative efforts with other agencies to ensure mutual local, state, federal, and international understanding of aviation noise.

Wake vortices are "horizontal tornados" created as a consequence of aerodynamic lift produced when aircraft move through the air. Limited prediction capabilities regarding the formation and propagation of wake vortices require that aircraft be conservatively spaced during approach and landing maneuvers to avoid hazardous windshear-like effects. Wake-vortex concerns constrain airport operations and threaten to confound many promising concepts to enhance capacity, including the application of simultaneous approaches to closely spaced parallel runways. Vortices from aircraft 200 feet above the ground have been observed to move over 2000 feet laterally. While the potential hazard is assumed to be relatively low, there is cause for concern with regard to simultaneous operations during IFR conditions, as pilots lack visual cues, such as the position of proximate aircraft, that can aid in avoiding wake vortices. The wake-vortex hazard may also limit the capacity-enhancing potential of conducting operations on multiple approach paths, which the MLS is able to accommodate.

Wake vortex has been an RE&D topic for more than a decade, involving the participation of NASA and the DoD. Knowledge gained to date has allowed safe longitudinal in-trail separations, ranging from 3 to 6 miles, to be tailored for various combinations of traffic streams. Recently, efforts have focused on rotorcraft wake-vortex and downwash phenomena and vortex motion and decay between parallel runways. Key objectives now include new computer models to aid wake-vortex forecasting and avoidance and the evaluation of onboard wake-vortex detection system concepts, with a goal of developing an operational wake-vortex avoidance and advisory system by the end of FY 1992.

Projects which support airport initiatives are:

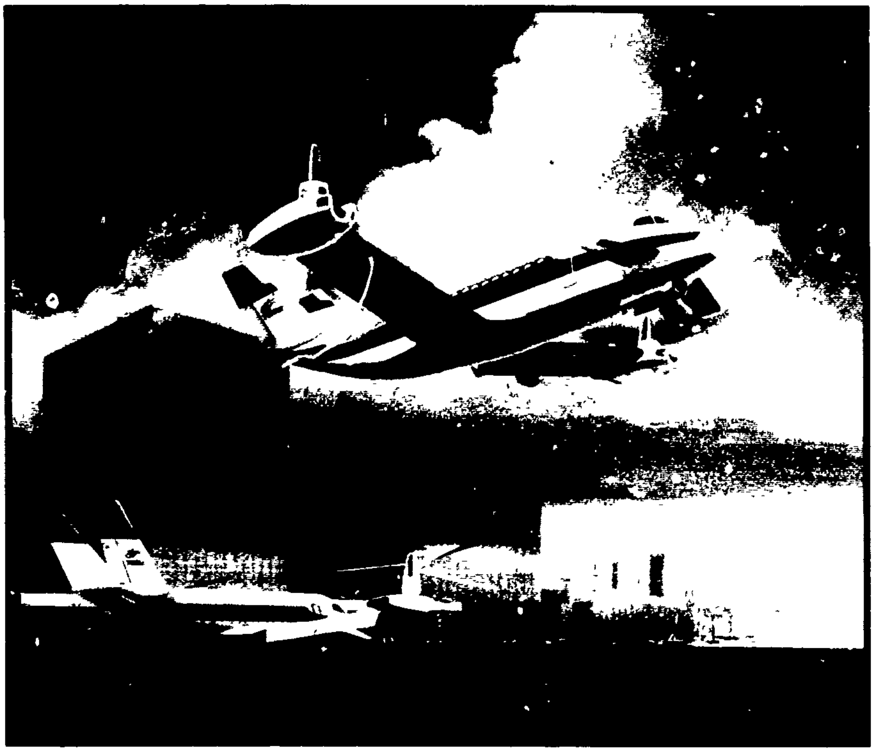
- 2.7 Simulation Model Development and Validation (SIMMOD)
- 2.8 National Airspace System Performance Analysis Capability (NASPAC)
- 2.9 Airspace System Models
- 3.6 Airport Surface Traffic Automation (ASTA)
- 3.7 Airport Capacity Improvements
- 3.11 Wake-Vortex Avoidance and Forecasting
- 3.16 System Concept Definition
- 10.1 Pavement Strength, Durability, and Repair
- 10.2 Airport Safety
- 10.3 Airport Capacity and Delay
- 10.4 Airport Capacity Task Force Studies
- 10.5 Airport Capacity Enhancement Planning
- 10.6 Terminal/Landside Traffic Modeling
- 10.7 Heliport/Vertiport Design and Planning
- 10.8 Environmental Activities

4.3.2 Tiltrotor

Combining the advantages of both rotorcraft and fixed-wing aircraft, the tiltrotor is a new technology on the civil aviation horizon. Because of its unique operating characteristics, the tiltrotor could provide convenient air connections between major metropolitan centers, thereby easing congestion at increasingly crowded hub airports. Tiltrotor service also has the potential to expand air commerce in markets where there is now little growth. The Port Authority of New York and New Jersey, for instance, views the tiltrotor as a major transportation asset that could facilitate over $1 billion of additional economic activity within the New York-New Jersey region.

The tiltrotor has civil air travel potential for trips of about 300 miles or less. This vehicle can take off and land vertically, like a helicopter, allowing additional operations at congested airports independent of overburdened runways, or at dedicated "vertiports" near city centers.

Airborne, it can tilt its rotors for use as propellers to achieve speeds and operating efficiencies comparable to fixed-wing, turboprop aircraft and far greater than those of conventional rotorcraft. It is conceivable that by the turn of the century, the tiltrotor could enable travelers to fly more directly to and from their downtown or suburban destinations.



Future Tiltrotor/Vertiport Aviation System Concept - Courtesy of Bell Helicopter, TEXTRON, Inc.

The FAA is working closely with NASA and the DoD to follow the development of a civil tiltrotor. A five-point tiltrotor program has been initiated which establishes a special tiltrotor project office, shaves 5 to 8 years off of the usual civil airworthiness certification process through concurrent civil and military flight testing, accelerates the development of pilot training and certification criteria, begins RE&D efforts to assess and address current system infrastructure and airspace procedural deficiencies, and allows cooperative planning with local communities for the development of a national system of vertiports. In August 1988, the aeronautical community filed a formal request for certification of a civil tiltrotor.

Currently, RE&D effort is focused on several objectives that will support operational use of the tiltrotor. An operational requirements analysis is under way to identify tiltrotor requirements not specifically addressed in the NAS F&E Plan. Work is also in progress to devise new or revised air routes and to develop procedures and standards for managing the flow of tiltrotor traffic into, through, out of, between, and within terminal areas with the goal of allowing all-weather, simultaneous fixed, and rotary-wing aircraft operations. Terminal instrument approach procedures for decelerating approach paths are being developed that will permit tiltrotors to perform precision approaches and departures using the MLS. Draft procedures are being evaluated at the FAA Technical Center using an S-76 helicopter equipped with MLS and area navigation equipment, with promising results to date.

Work is also advancing on developing obstruction avoidance techniques that will permit flight in obstacle-laden, low-altitude environments with the same level of safety that has been established for other commercial service. Computer models will be developed and used to predict demand and simulate tiltrotor operations. These analyses will be used to address issues relating to public safety and the environment, aircrew certification, precision approaches into vertiports, and terminal ATC procedures. Efforts are also under way for the analysis of noise, predicted traffic flows, and effects on ATC procedures. In addition to these programs, the FAA is undertaking cooperative research with several other organizations. Joint efforts are under way with NASA on the research and development of the rotorcraft simulator technology necessary for testing and evaluation of human performance associated with tiltrotor operations. The FAA is also participating in DoD ground and flight testing of the V-22 Osprey. Goals have been set, aimed at readiness for provisional certification of a civil nonpressurized tiltrotor in FY 1992 and full certification of a pressurized version for passenger commercial service by late 1995 -- at least 5 years ahead of foreign competitors.

Projects which support tiltrotor initiatives are:

3.8 Rotorcraft/Power Lift Vehicles IFR Operations Evaluation

3.9 Rotorcraft/Power Lift Vehicles ATC Procedures

3.12 Rotorcraft Separation Standards

9.3 Rotorcraft/Power Lift Vehicles Obstruction Avoidance

10.7 Heliport/Vertiport Design and Planning

11.5 Rotorcraft Simulator Standards

11.6 Rotorcraft/Power Lift Vehicles Display and Control Studies

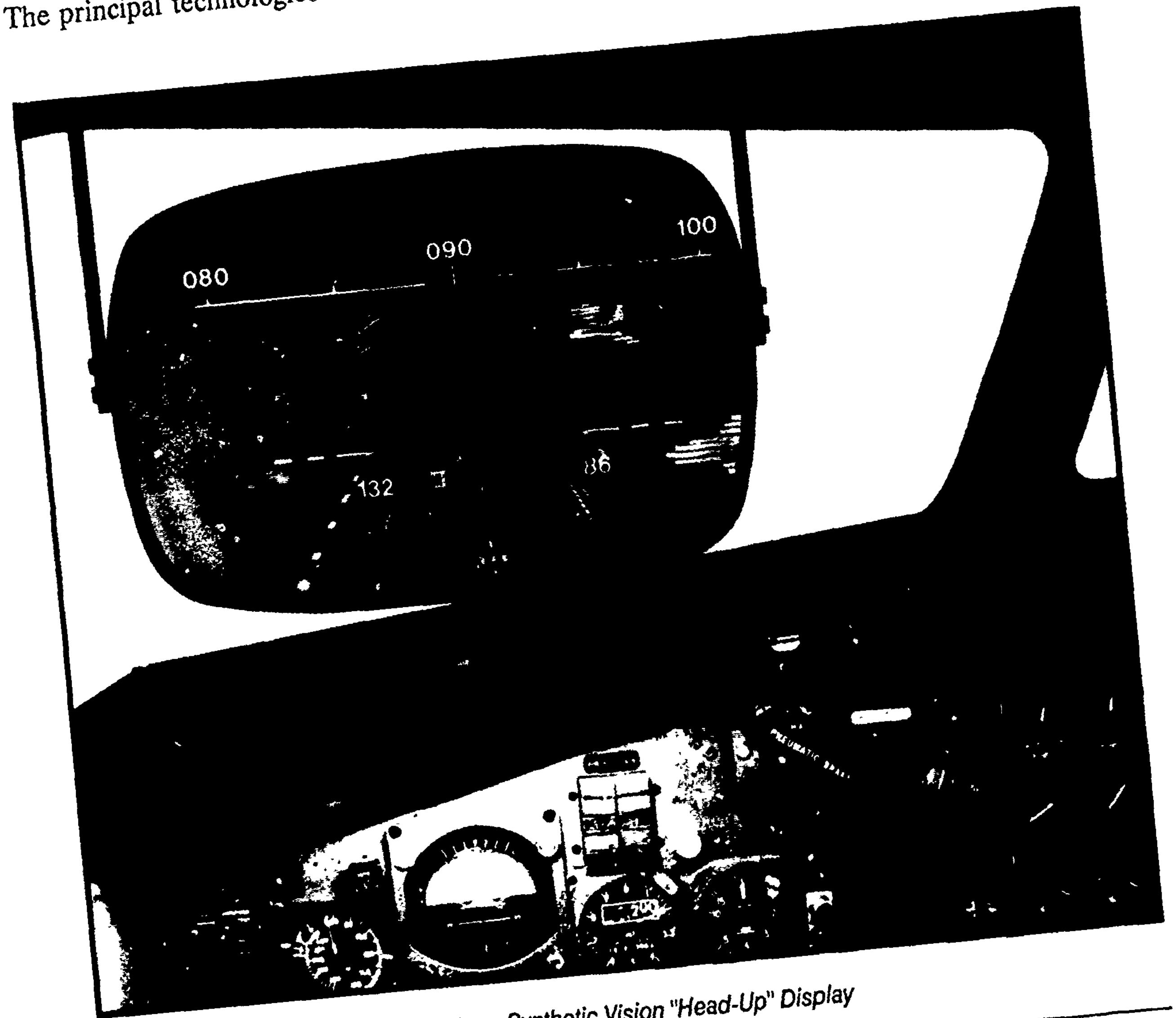
4.3.3 Vision Enhancement for Pilots

Aircraft have been landed safely in almost all kinds of weather for years. However, there are still times when it is essential to hold or divert to another airport, typically when low visibility prevails. The FAA is therefore intently seeking better ways of allowing planes to land, regardless of weather conditions. Accomplishment of this objective promises to result in improvements in aviation system capacity, safety, and efficiency.

One RE&D initiative under way, called "synthetic vision," would provide a cockpit-based supplement for ground systems. This project builds upon a lengthy series of efforts designed to provide visual assistance to pilots. Synthetic vision would offer self-contained navigation, guidance, and vision augmentation for nighttime, all-weather operations. A "head-up" display in the pilot's windshield field of view will be used to combine inputs from navigation, guidance, aircraft, and imaging sensors. The synthetic vision concept promises substantially improved capability without expansion of ground facilities, as well as reduced pilot workload and increased safety.

The development program is being conducted jointly by the FAA, DoD, and the aviation industry. Specific areas covered by FAA RE&D are requirements definition, technology surveys, and the development of statements of work for competitive contract awards. Also included are the initiation of system design studies, certification issue analyses, simulation activity, sensor integration planning, and flight test planning. A demonstration flight to show the validity of the concept was successfully conducted in July 1988.

The principal technologies under investigation for synthetic vision are: wide field of view



Mock-up Synthetic Vision "Head-Up" Display

raster/stroke head-up displays, active millimeter-wave radar, passive millimeter-wave sensor, information fusion, and image-enhancement techniques.

Millimeter-wave techniques have already been demonstrated to provide the effective imaging of runways, even in Category III visibility conditions, the most demanding of the defined standard instrument landing environments. A planned technology demonstration program will include examination of trade-offs between two of the candidate microwave frequencies, 35 gHz and 94 gHz. Both frequencies offer sufficient transmission of energy through fog or rain. Studies will consider trade-offs such as antenna size (smaller being preferred) versus image resolution (where a larger antenna size is beneficial). Development and system integration of a functional prototype system is scheduled for completion during FY 1990.

Work in FY 1989 will build on the foundation described above and provide the essential start-up procurement funds to develop and test candidate sensors, displays, and image-processing techniques. It will involve use of a test aircraft and simulator facility, static tower testing, and the evaluation of candidates for full-prototype development. Studies of certification will continue and cost-benefit analyses will be initiated in FY 1989. Toward the end of FY 1989 and through FY 1990, an airframe contract will be competitively awarded to effect the full cockpit integration of the prototype sensor, display system, computers, and electronics with the flight management system.

In addition to the use of aircraft as test vehicles, the demonstration program contemplates laboratory testing with a motion-base flight simulator to address human performance considerations. The simulator will be used to develop operational procedures, optimize image parameters, and measure pilot performance. It will also be used for resolving various certification issues in anticipation of widespread application.

The synthetic vision program will capitalize on new technologies, innovative contracting, industrial investment, interagency cooperation, and the previous experiences of similar programs. It has successfully demonstrated and documented the use of millimeter-wave imaging systems as a cost-effective tool for aircraft landings in low ceilings with limited visual range. Synthetic vision is a near-term, achievable, positive step toward meeting the challenges of a safer, more efficient aviation system of the future and will contribute to the elusive goal of all-weather aircraft operations.

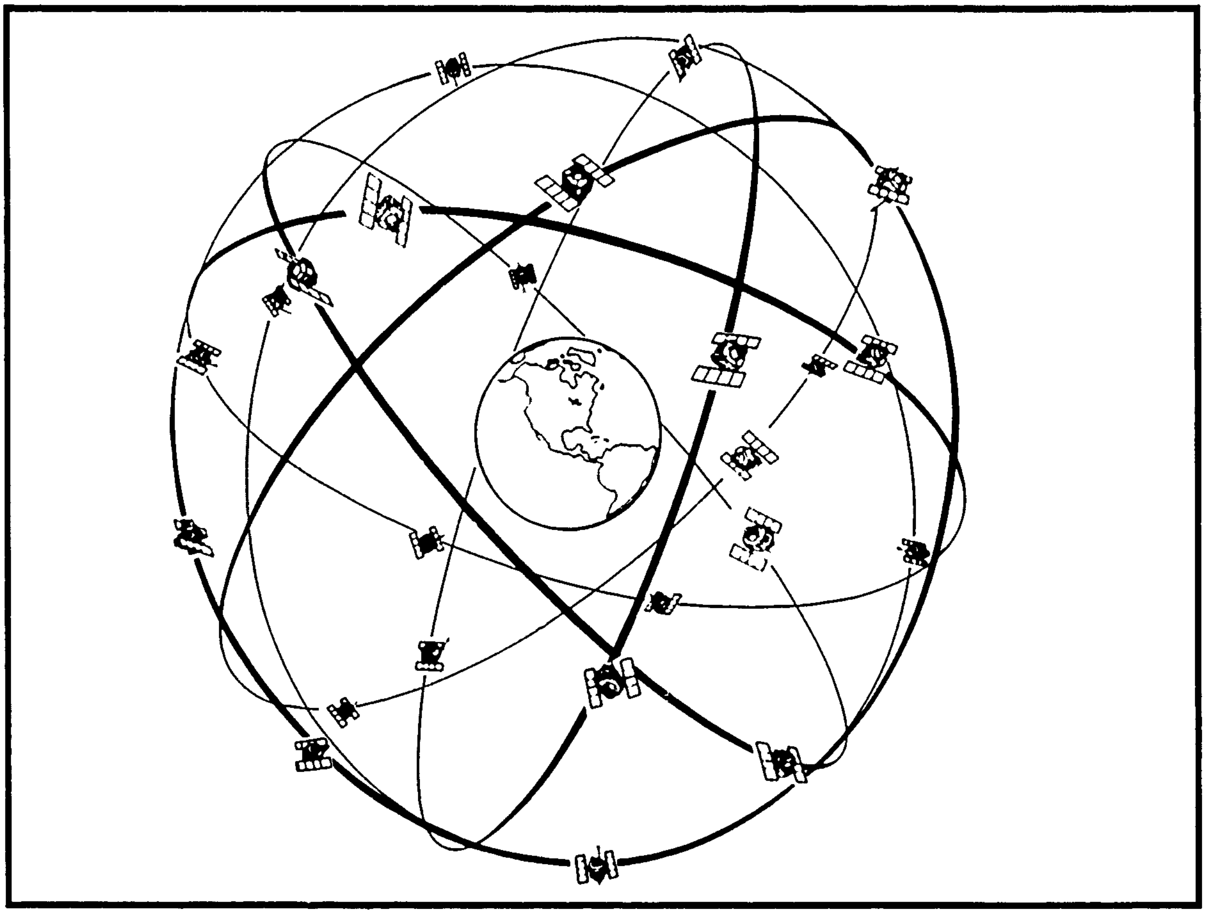
The vision enhancement initiative is included in Project 3.16, System Concept Definition.

4.3.4 Satellite Applications

The significant potential of satellite-based applications for enhancing aviation, well understood for over 2 decades, is nearing fulfillment as a consequence of advancing technology and worldwide system implementation. Satellite-based systems offer tremendous line-of-sight coverage over vast areas, from sea level to the upper reaches of the atmosphere and beyond. C/N/S applications of satellites are especially attractive for airspace wherein ground-based coverage is ineffective (such as at lower altitudes), uneconomical, or altogether infeasible (i.e., oceanic airspace). Advances in satellite-based C/N/S services promise to facilitate greater use of automated control concepts; remove fixed-routing constraints; and provide higher levels of safety, reliability, and efficiency. Anticipated satellite navigation systems should provide suitably equipped aircraft with supplemental or sole-means navigation for nonprecision approach guidance in remote areas where none would otherwise be available.

Substantial national and international agreement has been reached on the merits of satellite technology applications for aviation. Special Committee 155 of the Radio Technical Commission for Aeronautics and the International Civil Aviation Organization's (ICAO) Future Air Navigation Systems Committee have concluded that the exploitation of satellite technology is a viable option that can overcome present deficiencies and is the key to meeting future global C/N/S needs.

By the year 2000, an intercontinental flight could be guided by a satellite navigation system that pinpoints aircraft position to within 100 meters or less. Use of other techniques would permit achievement of much higher accuracy. Satellite altimetry, which could be relied upon during very high altitude flight, would also provide a valued crosscheck on the aircraft's barometric altimeter in lower flight regimes. Airline dispatchers and maintenance personnel could monitor the aircraft's flight progress and vital signs through a satellite data link, as well as communicate with the flight crew; communications would also provide in-flight telephone service to passengers.



GPS Global Navigation 24-Satellite Constellation

The safe and orderly incorporation of satellite technology into our aviation system is a major challenge. Satellite system integrity, coverage, and availability all pose unique problems within the context of ATC system safety. In the near term, significant applications will include air-ground digital data links through commercial communications satellites, and area navigation capability using the GPS. The most substantial benefits from satellite technology, however, will be derived in the 1990s, once ICAO adopts formal satellite-based C/N/S standards.

The FAA's heightened and accelerated pursuit of satellite-based technology is a new direction for the agency. Current efforts focus on the development of complementary satellite-based applications, ADS, and the GPS.

Complementary Satellite-Based C/N/S Applications

The FAA is increasing RE&D efforts toward an orderly incorporation of complementary satellite-based C/N/S applications into the aviation system. Emphasis will be placed on civil aviation applications of the GPS, near-term introduction of automatic ADS in oceanic airspace, and prompt resolution of mobile satellite policy issues. The ADS concept involves relaying aircraft position information derived from onboard navigation systems to ATC facilities using satellite data-link communications. A fundamental priority is the development of a comprehensive architecture which integrates C/N/S components in an orderly fashion so as to reduce overall costs and efficiently use the frequency spectrum available for mobile satellite services. The role of satellites in supplementing or eventually replacing ground-based C/N/S services will also be clearly defined, along with the benefits and costs of various alternative scenarios for 1995 and beyond.

Automatic Dependent Surveillance

Perhaps the most significant satellite application on the horizon is ADS. This system is expected to dramatically enhance safety and efficiency by providing a "pseudo-radar" control in airspace now beyond radar coverage. Since radar coverage extends only a short distance beyond the coastline, air traffic over the oceans is controlled much as it was before the advent of radar displays in the 1940s. Inertial navigation systems, although improved over the years, are still subject to inadvertent position errors resulting from incorrect initialization, including way point entry, as well as progressive errors during an oceanic flight. Safety under such conditions dictates that flights be assigned to rigid route structures employing relatively large, capacity-wasting separations. Aircraft must often fly less-preferred, fuel-inefficient trajectories. ADS would overcome these problems. If implemented internationally, it would allow air traffic controllers to monitor flight paths to ensure that hazardous route deviations or potential collisions are recognized and corrected before disastrous consequences result.

Research activities are already under way to move ADS a major step closer to reality, and more are planned. A satellite communications testbed is being created at the FAA Technical Center to support the development and validation of the ADS function and ICAO standards and to recommend procedures for data-link and voice communications. In cooperation with air carriers, flight tests will be initiated in 1989 to track aircraft over the Atlantic using inertial navigation data uplinked to an Inmarsat satellite from an air cargo aircraft. Trials of aircraft-to-satellite linkages have been initiated at the FAA Technical Center using a Boeing 727. Performance requirements for navigation blunder detection are to be established this fiscal year, followed by two-way digital data-link requirements for air traffic command and control during FY 1990. Through FY 1993, extensive testing is planned using the ADS testbed and simulation facilities augmented with field-derived data. Mathematical and statistical models for estimating the risk of collision in the horizontal plane are being enhanced, and earlier estimates of collision risk in oceanic airspace are being updated. A new computer simulation of oceanic track intersections in an ADS environment is also under development. The FY 1990 RE&D program proposes a feasibility study of other satellite-based concepts, such as cooperative independent surveillance, as backup to ADS and other ATC applications.

Global Positioning System

The RE&D program addresses a number of specific questions which support the establishment of an FAA position on the preferred radionavigation mix for aircraft in the national aviation system. The operational coverage, reliability, and integrity of satellite navigation systems are particular concerns, with an emphasis on the GPS. "Integrity" is the essential quality having to do with assuring the pilot that he knows the operational condition of a system well enough to rely on it for safety, such as during a landing, when seconds count. As planned by DoD, the GPS does not possess sufficient integrity for use by civil aviation as a sole-means area navigation aid or nonprecision landing approach aid. Two approaches to the GPS integrity problem are being studied: a ground-based monitor which would transmit GPS integrity information to the aircraft over what is termed the GPS integrity channel (GIC) and a receiver-autonomous integrity monitoring which would use redundant measurements to determine the internal consistency of the GPS navigation solution. Combinations of satellite systems, such as the GPS, and a ground-based long-range navigation system, LORAN C, are being explored as possibilities for establishing an area navigation system that could replace VOR/DME at some point in the future. During FY 1989, the feasibility of establishing requirements for GPS/LORAN C will be determined. Suitable methods for coordinating LORAN C timing with GPS time will be identified by September 1988 for final evaluation of a working model of an integrated GPS/LORAN C system. A decision on GIC as a means of guaranteeing the integrity of GPS signals is expected in 1989. This will provide the option to move forward with GIC implementation so that GPS can serve as a supplemental landing aid for nonprecision approaches at rural airports.

Future Directions

Potential research initiatives being considered for the future include:

- Research on GPS interoperability in combination with navigation systems other than LORAN C -- While GPS with LORAN C is promising, combinations such as GPS/Inertial, GPS/OMEGA, or the interoperable use of GPS and other satellite navigation systems should also be examined.
- Research concerning the possible extension of ADS to the domestic airspace -- Work should be conducted to identify this system's potential to replace or supplement the use of ground-based radar as aviation prepares to enter the 21st century.

Satellite-based technology will play a significant role in the future aviation system. The FAA RE&D program will provide the basis for rapid incorporation of this technology, enabling the U.S. to meet international commitments and greatly enhancing system safety, capacity, and efficiency.

Projects which support satellite applications initiatives are:

8.1 Satellite-Based Air-Ground Communications

8.2 Future Satellite C/N/S Systems Applications

4.3.5 Aging Aircraft

While the FAA's RE&D program has traditionally addressed airworthiness issues, recent events have spotlighted the need for an increased emphasis on safety issues related to aging aircraft. On May 17, 1988, House Resolution 450 was introduced which encourages the FAA to "establish a research and development program to study structural fatigue, wear, corrosion, and damage to aircraft resulting from age and intensive utilization, and to conduct nondestructive and destructive testing of older aircraft on a regular basis." A joint FAA/industry conference on the subject of aging airplanes was convened on June 1, 1988. Issues that arose from the conference are contained in a joint Aerospace Industries Association and Air Transport Association plan of action. This plan calls for the following: (1) investigations concerning causes of major structural failures and adjustments that may be necessary to the maintenance and inspection system; (2) improvements of methods for assessing structural conditions and detecting structural problems; (3) teardown inspections of aging airframes; (4) improvements to current nondestructive testing technology; (5) examination of the human performance involved in aircraft inspection; and (6) better communication between airlines, manufacturers, the FAA, and others in the aviation community.

The FAA is planning new research efforts to enhance aircraft and engine safety through a better understanding of the detection and causes of fatigue and the development of appropriate related practices and procedures for the prevention of further incidents that compromise the safety of air travel. In FY 1989, the FAA will initiate a major RE&D program to develop the technology to predict, uncover, and prevent incipient fatigue, corrosion, and cracking - including multiple site cracking - in aircraft fuselages and engines. The objective of this program is to generate technical data to support certification standards, performance criteria, advisory materials, and airworthiness directives relating to the safety of in-service metal aircraft and engines.

The Federal Aviation Regulations require fail-safe design features for transport aircraft. Historically, this requirement was achieved by redundant airframe and engine installation design and is achieved in modern airplanes through use of a "damage-tolerant" methodology. With this methodology, structural components are designed to maintain their integrity, although damaged, until a crack has grown to a size that can be detected. The inspection interval for each major safety-critical assembly is determined by the number of flight or operating hours required for a crack to grow from the size at which it could first be detected to that at which dynamic load would cause it to grow in an unstable manner and fail the component.

Damage-tolerant design procedures are generally based on the assumption that an isolated crack exists in an otherwise sound structure. While this is a good assumption for new and "young" airplanes, the isolated crack does not reflect the condition of airplanes flown up to and beyond their original design fatigue life. For aging airplanes, components may have cracks at multiple sites which can decrease the ability of the structure to contain a fracture. Under dynamic loading, crack propagation can become unstable and cause a component failure. The resulting transfer of load to the rest of the structure can cause one or more additional failures, and the process can cascade to catastrophic failure of a major assembly.

Structural Damage from Nearly Invisible Fatigue Cracks

Presently, the experience base of multiple site cracking of aging aircraft is small, but even these few known instances have resulted in great damage and loss of life. In 1981, a Taiwanese aircraft suffered an in-flight breakup with the loss of over 100 lives. An investigation by the government of Taiwan attributed the accident to failure of corroded fuselage belly skin panels. Another case of multiple site cracking occurred on a Japanese aircraft in 1985. Multiple cracks formed in the aft pressure bulkhead and were not detected by the existing inspection program. The bulkhead failed in flight, which led to a crash with the loss of several hundred lives. Most recently, multiple fatigue cracks were found to have existed on the Aloha Airlines Boeing 737-200.

As presently planned, this year's RE&D will focus on the following areas: (1) identification, documentation, and analysis of the structural integrity of in-service airplanes and engines; (2) determination of the failure mechanisms relating to aging, fatigue, corrosion, crack propagation, residual strengths, and the deterioration of aircraft; (3) evaluation of current nondestructive inspection techniques and equipment for use on aging aircraft and engines; (4) development of training materials for inspection and maintenance personnel; and (5) human performance research to investigate how design, operation, maintenance, and inspection procedures can be affected by the people who do the work.

Project 11.8, Aging Aircraft, has been initiated to address safety problems in this area.

4.3.6 Human Performance

The safety, reliability, and efficiency of our aviation system depend upon the men and women who work in it. Human performance research looks at how people function in their jobs as pilots, controllers, maintenance technicians, and ground support personnel. Knowledge and consideration of human capabilities and limitations in aviation systems design and operation offer the greatest potential for increasing fligl safety.

A number of influences are leading to an increasingly complex aviation system which places new and different demands on system operators. For example, the management of air traffic is becoming increasingly complicated due to the need to move larger numbers of aircraft quickly, yet safely, through the system. To expand operator capability, tasks are being increasingly automated on the flight deck and in ATC facilities. However, as discussed in Chapter 3, the dynamics of human interaction with highly automated systems is not yet fully understood. The optimum levels of automated tasks need to be determined, as well as the long-term effects of automation on human performance.

These issues have prompted the FAA to place greater emphasis on aviation human performance. Agency capabilities will be expanded through formal working agreements with NASA, the DOT's Transportation Systems Center, the Civil Aeromedical Research Institute (CAMI), and various universities. Human performance research to be conducted or sponsored in FY 1989 will concentrate on three areas: flight crews, air traffic controllers, and aeromedical research.

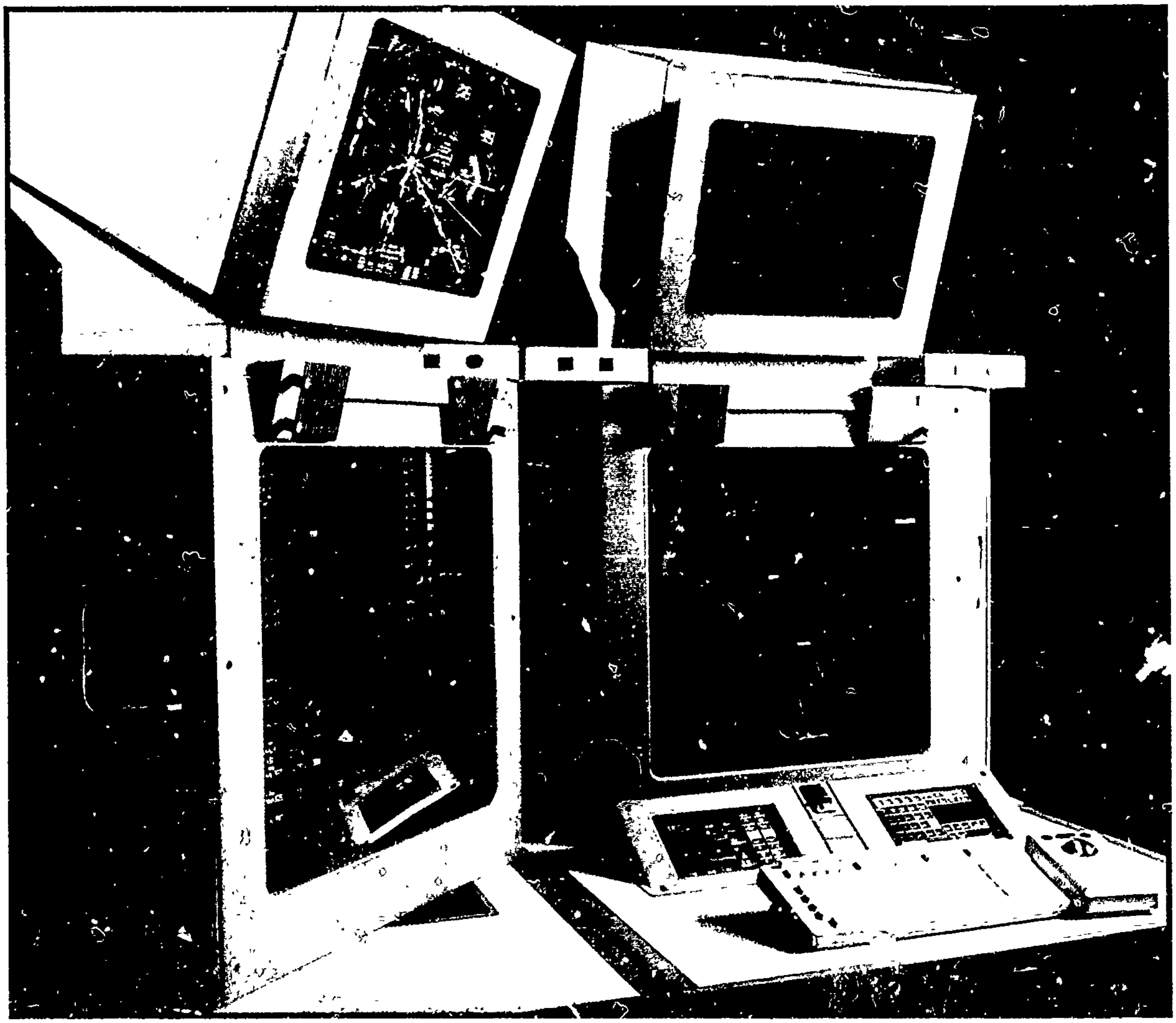
Flight Crew Performance

Pilot error has been identified as a contributing factor in 66 percent of air carrier fatal accidents, 79 percent of commuter fatal accidents, and 88 percent of general aviation fatal accidents.

To reduce the number of accidents in the face of mounting demands on the flight crew, research will address the design and certification of flight deck systems and revised crew training requirements. In FY 1988, studies of safety data were initiated to define human performance problem areas that contribute to accidents and incidents caused by human error. In FY 1989, the knowledge gained will be used to investigate improved crew interfaces to automated systems; improve the design of displays, charts, and procedures; enhance training methods; and develop effective methods for the management and transfer of information to the flight crew. Work will be initiated to develop methods for objectively measuring flight crew performance to facilitate the evaluation and certification of advanced technology cockpit displays, cockpit procedures, and control systems, and to supplement certification criteria for new systems. Interviews, observations of crew performance, and analyses of databases will be conducted to determine the need for changes in requirements for flight training. Research will also be conducted to develop crew performance criteria for use in the evaluation and certification of rotorcraft displays and controls and to establish guidelines for the design and evaluation of rotorcraft training simulators.

Performance of Air Traffic Control Specialists

The role of the controller in the future automated ATC system is receiving considerable study as part of the development of this system. It is necessary to continually assess the role of the controller and to identify and resolve man-machine interface limitations that



AAS Sector-Suite Man-Machine Interface - Photo courtesy of IBM

reduce the safety or efficiency of ATC operations. The controller human factors program recognizes the fact that automation systems should be designed to both detect and accommodate for human error. Thus, the human performance aspects are made an integral part of the design of each new automation function. For example, successful design of the AAS sector suite has involved continual input from a controller evaluation team. As a result of this positive experience, a laboratory will be established at the FAA Technical Center to permit controllers' rapid evaluation of other new automation concepts. An engineering testbed which permitted a real-time controller interface was used in the evaluation and modification of AERA 1 and 2 and will be used in the development of AERA 3 and terminal automation improvements. The feasibility of using artificial intelligence in training systems for air traffic control specialists will also be investigated, and studies will be conducted to determine visual requirements for such personnel.

Aeromedical Activities

Aviation medicine research is directed toward increased awareness of physiological factors associated with accidents and consequent actions by the agency to correct areas within its certification purview, reduction in damages to aircraft and facilities, reduction in injury and loss of life in accidents, and more relevant airman and controller medical certification procedures with possible reductions in time and funds for the affected populations. The CAMI Toxicology Laboratory will continue to support aviation accident investigation through analysis of tissue specimens and on-site accident investigation. One major effort at CAMI will be a study of the environmental impact of human performance on the maintenance, inspection, and testing of air carrier aircraft. Activities in the Work Force Optimization Research Program will include designing tests used for the selection of air traffic control specialists and aviation safety inspectors, evaluating their selection and training processes, monitoring personnel workload and job-related stress, and assessing the job climate for the FAA's work force. Studies will also be conducted to support the needs of the Federal Air Surgeon in the areas of aeromedical certification standards, accident investigation, occupational health, and aeromedical education.

Future Directions

The most important research to be initiated in FY 1989 will yield products ready for application early in the 1990s. Products of this research will include methods and procedures for evaluating human operators in automated systems, certifying advanced technology airplanes and rotorcraft, and identifying system characteristics that promote human error. Enhanced training requirements and training aids will be developed for flight crews and air traffic control specialists with emphasis on automated systems and other topical areas (e.g., cockpit resource management). Nearly all of the human performance research and development activities in FY 1989 are directed toward enhancing operator capabilities and minimizing the potential for operator error. Such improvements will enhance safety, increase operational efficiency, and provide cost savings.

Two important future research areas anticipated for FY 1990 and beyond are additional cockpit resource management (CRM) work, including development of a CRM training aid for small airline operators and the evaluation of the effectiveness of CRM training programs, and human performance research related to aircraft design, inspection, and maintenance.

The CRM initiative is important because smaller airline operators have significant problems with crew coordination due to high personnel turnover and lack of the sophisticated simulator-based training programs used by larger carriers. The proposed research would involve adapting portions of the CRM training programs of larger carriers for use by smaller operators, developing training programs and aids, and evaluating the effectiveness of implementing such training programs.

The second initiative is intended to support the increased emphasis within the FAA's RE&D program on aging aircraft. The FAA/industry conference and other sources have recently stressed the need for human performance research to support and guide regulatory and advisory actions concerning aging aircraft. Four broad areas of human performance research have been identified: communications, vigilance, environment, and personnel. The FAA believes that such a research initiative would contribute significantly to aviation safety through better understanding of human limitations in the design, inspection, and maintenance of aircraft.

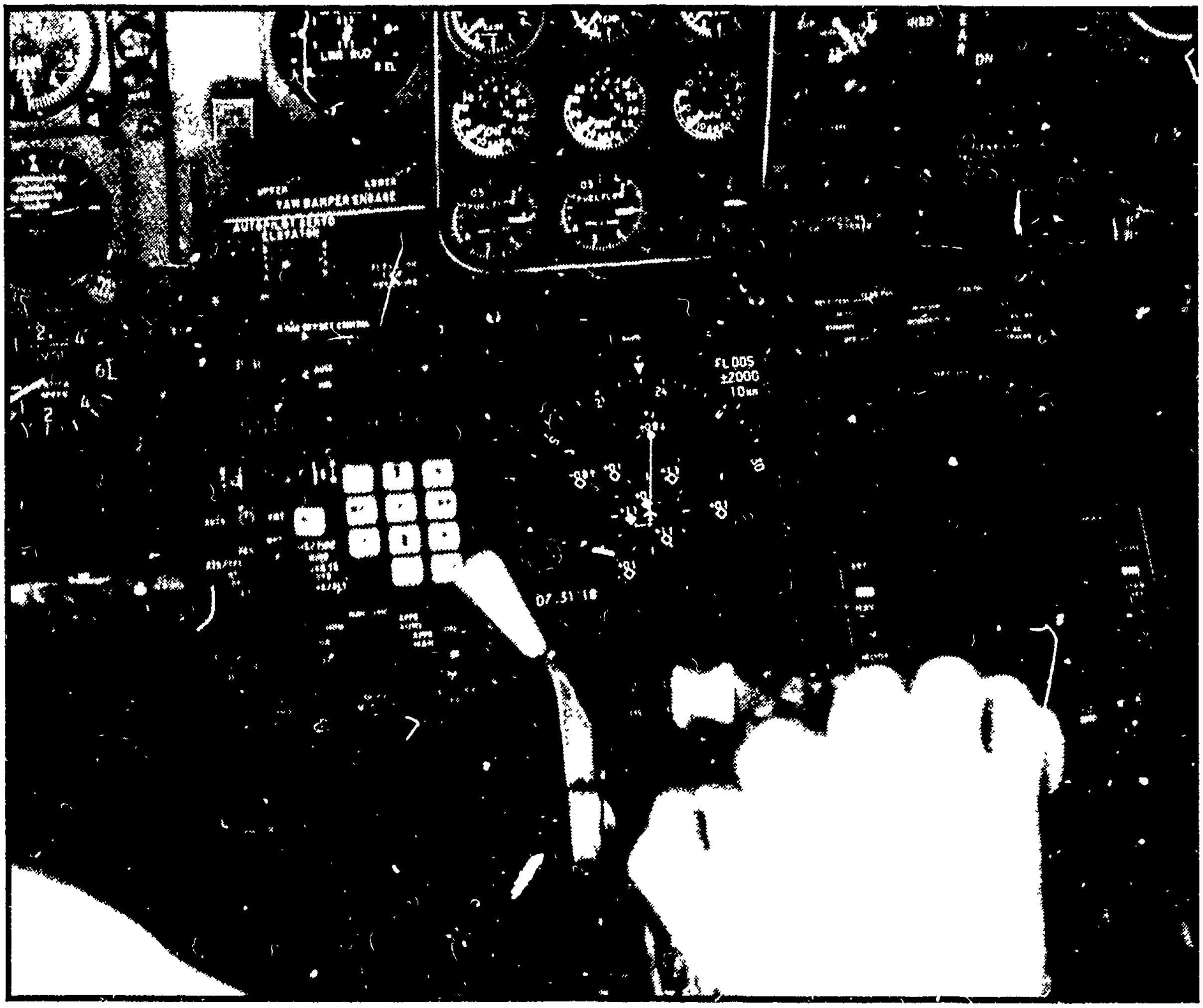
Projects which support human performance initiatives are:

- 12.1 Work Force Optimization Research
- 12.2 Human Performance Research
- 12.3 Protection and Survival
- 12.4 Aeromedical Program Support
- 14.1 Controller Human Factors
- 14.2 AI Applications to Air Traffic Control
- 14.3 Causal Factors in Accidents and Incidents
- 14.4 Human Performance Assessment and Improvement
- 14.5 Information Transfer and Management
- 14.6 Aircraft Automation
- 14.7 Control and Display Technology
- 14.8 ATC Weather Information Transfer
- 14.9 Interactive Voice Systems
- 14.10 Flight Deck Certification Criteria
- 14.11 Flight Crew Certification and Training
- 14.12 Human Factors and Regulatory Support

4.3.7 Collision Avoidance

An effective air traffic control system remains the central approach to ensuring safe separation between aircraft. The existing ground based ATC system, augmented by flight crew vigilance, provides a very high level of safety. Nevertheless, the realities as well as the perceptions of the possibility of collisions, along with their typically severe consequences, contribute to the widely held view that additional ways to ensure aircraft separation must be found and implemented. The FAA's RE&D program is providing leadership in this quest.

The significance of the problem of collisions has been widely documented. At issue, in addition to actual collisions, are near midair collisions, operational errors (the loss of legal flight separation around an aircraft which is attributed to the ATC system), and runway incursions (infractions at airports involving aircraft during takeoff or landing).



Prototype TCAS III Display Depicted in a Jetliner

Airborne Collision Avoidance

The search for an airborne collision avoidance device was initiated by the airlines in the 1950s. It was believed that such a system was needed to provide an independent backup for the FAA's ground-based ATC system and to ensure safe aircraft separation in airspace outside the system's coverage areas. By the end of the 1970s, industry had developed several collision avoidance systems, and proponents were advocating adoption of certain designs. Each of these designs required equipment to be aboard both of the aircraft involved in a potential collision. This meant added expense for the aircraft owners, as well as a federal mandate to ensure that enough aircraft installations were made to provide a significant increase in the level of protection for those seeking it.

The FAA proposed a system design that would recognize the proximity of all similarly equipped aircraft as well as those having only an operating air traffic control radar beacon transponder on board. Since more than 100,000 aircraft, or about 65 percent of the existing fleet in the mid-1970s, already had the transponders, it was believed that this approach, termed BCAS (beacon collision avoidance system), would offer adequate protection without the need to mandate its use with all aircraft. The FAA's RE&D program has provided for much of the development of the resulting system. Today's result, TCAS, requires the "threat aircraft" to be operating with a Mode C transponder. TCAS operates at maximum advantage if the threat aircraft is also equipped with an altitude encoder. The design includes sophisticated technology in order to operate in high-traffic-density areas and "judge" the intended courses of threat aircraft.

TCAS offers a choice of three levels of complexity, ranging from a simple visual and auditory warning in the simplest and least expensive unit (TCAS I) to a combination of warnings and recommended evasive maneuvers in altitude or heading with the most complex (TCAS III). The FAA believes that TCAS offers the best solution to the need for a collision avoidance system, having true independence of the present ground-based system of air traffic control. A position based on this belief has been maintained consistently for several years by oversight groups and the aviation industry.

Looking ahead to FY 1990, a limited installation program will be conducted for TCAS III, including full flight testing at the FAA Technical Center and approximately 6 months of operation in normal revenue service. Studies pertaining to TCAS III integration into standard and "glass" cockpits are being planned with NASA. The initial installation program for TCAS I will also be enhanced.

TCAS is presently maturing. Although it is still the principal focus of the FAA's collision avoidance RE&D effort, several future program opportunities exist with the potential for further improvements in the level of protection against in-flight hazards and runway incursions. These are described below.

Detection of Intruders in Terminal Control Areas

There is a problem in the Los Angeles area resulting from the intrusion of unauthorized general aviation aircraft into the terminal control area. The tragic midair collision over Cerritos, California, in 1986 resulted from the lack of an operating beacon transponder aboard one of the aircraft. In FY 1990, RE&D work will focus on detecting conflict alert/terminal control area violations and integrating the outputs into the automated radar terminal system displays. It is believed that this project can provide quantitative information about a problem whose dimensions have heretofore been subjectively estimated.

Surveillance of Runway Incursions

Runway incursions are a growing category of undesirable occurrence usually involving a hazard. They always involve one of the following: operational errors; vehicle operator or pedestrian deviations; or pilot, vehicle operator, or pedestrian judgmental errors. In 1987, 386 runway incursions were recorded at U.S. airports.

The technology of radar detection of aircraft and vehicles on the ground at airports is well developed. ASDE has been deployed at a number of major airports. The availability of Mode S data-link capability and its expected widespread use in terminal areas offers the prospect of an integrated Mode S surface data link and airport surveillance system. In FY 1989, design and construction will be started on a transportable, integrated ASDE/Mode S data-link testbed. Construction of the testbed is to continue in FY 1990 and be completed in FY 1993. The objective is to assess the practicality of such a system, operating in an automated mode, as an aid both to surveillance and data-link communications at an airport. It is believed that a significant reduction in the number of runway incursions could result from its successful development and deployment.

Projects which support collision avoidance initiatives are:

6.4 Surface Traffic Surveillance

6.6 Special Surveillance System

9.1 Traffic Alert and Collision Avoidance System (TCAS)

4.3.8 Avoiding Atmospheric Hazards

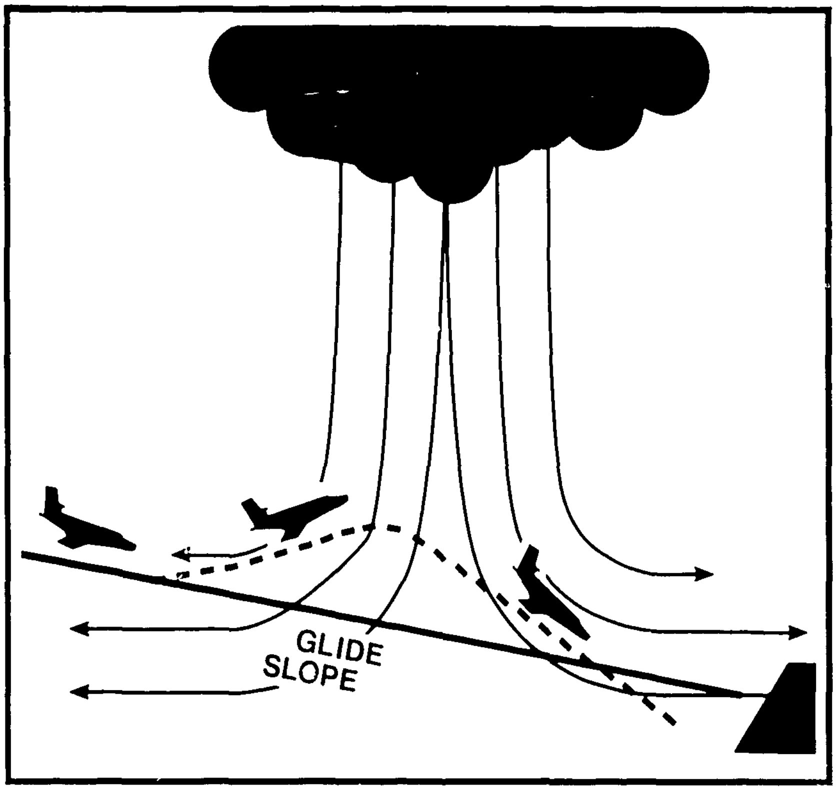
The effects of hazardous atmospheric conditions, especially windshear but also phenomena such as lightning and icing, are clearly a significant concern to the aviation community due to their impact on aviation safety. The Air Line Pilots Association, the Aircraft Owners and Pilots Association, and other aviation community groups have testified that the ability to acquire, interpret, and distribute accurate and timely weather data is a critical factor in aviation safety.

For aviation purposes, the FAA has statutory responsibility for disseminating weather information, much of which is derived from the National Weather Service (NWS). The goal of the FAA's RE&D program in this area is to improve the timeliness and accuracy of weather information in order to reduce the number of weather-related incidents and increase both system capacity and fuel savings by eliminating weather-related delays. Elements of the program are conducted in close cooperation with NWS, DoD, and NASA. RE&D in this area is aimed primarily at improving the capability of existing equipment, developing and testing new detection systems, and developing and testing techniques for interpreting and disseminating weather data.

Due to its severe hazard to aviation safety, windshear is the primary focus of the FAA's RE&D program. Activities include the development of ground-based and airborne detection systems and of technologies for automating the communication between ground and air. The RE&D program also addresses other atmospheric hazards to aviation safety, particularly icing and lightning.

Windshear: A Significant Hazard to Arriving and Departing Aircraft

Windshear is an abrupt change in wind speed or direction. It usually is not a serious hazard for aircraft en route between airports at normal cruising altitudes. During landing or takeoff, however, a strong, sudden windshear can be deadly for an aircraft. The most hazardous form of windshear during approach and departure is the microburst, an outflow of air from a small-scale but powerful gush of cold, heavy air that can occur beneath a thunderstorm or a harmless-looking cumulus cloud. As the downdraft reaches the surface, it spreads out horizontally, like a stream of water sprayed straight down from a garden hose on a concrete driveway. An aircraft that flies through a microburst can encounter a strong head wind, then a downdraft, and finally a strong tail wind that produces a sharp reduction in airspeed and sudden loss of the aerodynamic lift necessary to sustain flight. This can be a deadly sequence of events for aircraft during final approach or initial takeoff climbs. Windshear also can be associated with gust fronts, larger scale outflows, or cold air from thunderstorms, as well as with warm and cold air fronts.



Aircraft Encounter with Microburst Windshear

Ground-Based Windshear Detection

As it became increasingly clear that low-altitude windshear was responsible for a number of fatal accidents, research efforts were launched to develop detection techniques. Initially, it was believed that gust fronts were responsible for the crashes. In the late 1970s, the FAA developed the LLWAS, a ground-based network of wind instruments designed to detect gust front windshears at airports.

During that same period, Doppler weather radar, which is capable of showing the three-dimensional structure of storms relative to both wind and precipitation, became a research tool for meteorology scientists. Doppler weather radar allowed scientists to identify and study the windshear features produced by storms. This led to the discovery of the microburst and to an understanding of its structure and life cycle.

In 1980, the NEXRAD program was established by the FAA, the NOAA, and the U.S. Air Force. NEXRAD has the ability to detect microburst windshear. The goal of the NEXRAD program is to develop and install a national Doppler weather radar network for observing and predicting severe storms and other weather phenomena in the United

States. The FAA has concluded, however, that the planned NEXRAD information update rate of 5 to 6 minutes and the siting of the radar, which will often be many miles from an airport, will not provide sufficiently timely information on microbursts at airports to fully alert arriving and departing aircraft. (Microbursts are small, short-lived features. Their detection requires that the radar be located near an airport and have a faster, 1- to 2- minute information update rate.)

The FAA is currently developing and evaluating two systems to detect microbursts and other low-altitude windshear features of concern to landing and departing pilots. These are an expanded version of the LLWAS and TDWR.

The LLWAS program has already yielded significant safety results. Since implementation in 1975, the number of nonfatal and fatal aircraft incidents and accidents has dropped markedly. However, the initial configuration of the LLWAS has been found to be unreliable for detecting microbursts and is subject to false alarms. As a result, the FAA has undertaken a research program to develop an enhanced LLWAS, which will include an increase in the number and density of sensors in order to reduce the likelihood that microbursts will hit between the sensors without being detected. Other current research is directed toward expansion of the LLWAS to provide coverage out to 3 miles from runway ends, an LLWAS design for very large airports such as the new one at Denver, and software to incorporate new techniques for the mitigation of false alarms. Testing of an expanded network LLWAS and an algorithm providing full microburst detection capability has been successfully completed at the Denver Stapleton International Airport. At Denver and New Orleans, the LLWAS has been upgraded with these new capabilities and is now fully operational.

Despite the improved features of the enhanced LLWAS, it is not viewed by the FAA as the optimal solution to the windshear detection problem. For the most part, the sensors are located at the airport and cannot detect windshears that occur above ground or beyond the network periphery. The 1985 Dallas crash, for example, involved a microburst encountered beyond the airport's LLWAS sensors. The microburst was not detected until 10 to 12 minutes after the crash, when the microburst came closer to the airport and penetrated the network of sensors.

Though the enhanced LLWAS will remain a part of the overall windshear program as a supplement to the new Doppler radar systems, and although the FAA's optimal ground-based windshear detection system is TDWR, the FAA is performing a study to determine the benefits of linking the two systems. Properly located, TDWR can monitor the actual approach and departure paths of aircraft high enough and far enough from the runway to provide warning in time for corrective action by pilots. During the summer of 1988, the FAA's TDWR testbed was being evaluated in the Denver area and received positive media attention and high praise by the FAA and aviation observers when it was credited with probably averting one or more windshear disasters. The TDWR program has advanced to the acquisition phase for the hardware and first generation software capable of detecting windshear. In FY 1989, the FAA's TDWR research and development program will include further collection and analysis of radar data to determine features that can be used to better predict the formation of windshear conditions, continued documentation and testing of an advanced algorithm that will be incorporated into upgraded software which will detect precursors of microbursts and provide an advance warning of the formation of windshear conditions, consideration of the joint usage of data derived from TDWR and airport surveillance radar (e.g., ASR-9), and definition of an interface between Doppler weather systems and the LLWAS. Until the TDWR system is ready for deployment, terminal NEXRADs will be sited in the vicinity of airports to augment the windshear detection afforded by the enhanced LLWAS system.

Airborne Windshear Detection

Airborne sensors are desirable because they do not have the coverage limitations of ground sensors, do not depend on ground-to-air communications, and provide early warning directly to the cockpit. The FAA has undertaken a cooperative effort with NASA to develop the systems requirements for airborne windshear sensors that enable the flight crew to reliably detect hazardous windshear along an intended flight path with sufficient time to avoid it. The objective is to transfer technology to avionics manufacturers in order to accelerate development and certification of these sensors. Microwave radar and light detection and ranging technologies are currently undergoing assessment by the FAA and a consortia of manufacturers.

Automated Collection and Dissemination

Currently, air-ground communications are not always adequate to support the needs of pilots for real-time ATC and weather information. Controllers sometimes do not always have time to transmit weather information to pilots or are distracted from this task by more urgent demands to separate traffic.

The FAA is addressing this problem through the development of an automated digital air-ground data link. The Mode S data link will give pilots direct access to weather data, providing more timely weather information (including windshear alerts) and reducing the critical-time workload of controllers. To receive information via the data link in the future, aircraft will be equipped with a Mode S transponder, an onboard computer, and a computer printer or display. The FAA is also developing a ground-based weather communications processor which will act as the interface between aircraft equipped with Mode S data link and pilot-desired weather information. This processor will receive requests for weather data, decode the request, format the replies, and return them to the pilot. Aviation weather communications systems are expected to become operational beginning in 1990 or 1991.

Atmospheric Hazards Other Than Windshear

Icing

The RE&D program seeks to reduce the effect of icing on aircraft safety. One objective is the collection of the technical data necessary to develop certification standards and flight procedures for icing conditions for all categories of aircraft. Efforts in support of this objective include atmospheric icing characterization; development of improved certification guidance for anti-icing and de-icing equipment and calibration standards for icing instrumentation; and investigation of technologies associated with the detection of ice accumulation on an aircraft on the ground, including snow and ice particles that refreeze following de-icing with glycol-based fluids.

A second aspect of this program has the objective of providing pilots with a more timely, accurate delineation of actual and expected icing areas by location, altitude, duration, and potential severity. This research, a cooperative effort with the NOAA, DoD, and National Science Foundation, is designed to carry out the program defined by the National Plan to Improve Aircraft Icing Forecasts. The project will study the ability of the new generation of remote sensors to detect icing conditions, evaluate current icing forecast techniques, test promising new methods, and provide the technology transfer necessary to implement the best techniques into the day-to-day operations of the NWS. Preliminary work leading to a detailed program plan was begun in FY 1987 and will continue through FY 1989. In FY 1990, a major 6-year program will begin to provide all the basic data needed to support development of new forecasting techniques and determine the ability of the new generation of remote sensors to detect and monitor icing conditions.

Lightning

The potential for lightning to disrupt safety-critical electronic flight control systems is of increasing concern, as new aircraft are designed to take advantage of computer-based technology. RE&D in this area is conducted to assess the airworthiness of present and future aircraft in relation to these electromagnetic safety hazards. Efforts include the generation of a technical database on the hazard of lightning-induced EMI and an assessment of its adverse safety effects on aircraft and advanced flight controls. Such information is needed to provide a basis for the establishment, validation, and updating of airworthiness criteria.

Other lightning-related concerns involve the airworthiness of airframes constructed largely of nonmetallic materials. While aluminum airframes provide an excellent shield for the aircraft cabin interior by conducting lightning through the exterior structure, little experience has been gained concerning the consequences of lightning strikes on nonmetallic materials such as the graphite-epoxy composites which are gaining in popularity because of highly favorable strength-to-weight characteristics. This knowledge is to be derived through RE&D efforts currently planned.

Future Areas of Research

Potential future areas of research involve the integration of windshear information from ground and airborne sensors and of existing and planned windshear detection systems.

A new research project is slated to begin in FY 1990 to analyze and provide system requirements for proper integration of ground and airborne windshear information. The priority of these information resources will be identified and channeled to aircraft to aid flight crews in decision making and assist air traffic controllers with metering and spacing based on avoiding known windshear hazards. Initial efforts will be directed toward the analysis of flight crew and air traffic requirements for windshear information in order to determine how data will be integrated.

Another potential area of research involves the issue of the appropriate operational roles for and integration of the various near-real-time weather information devices being developed or in use. In addition to TDWR and expanded LLWAS, other systems being developed or in service include NEXRAD, ASR-9 radar, the lightning data system, and the automated weather observing system. There is a need to determine the appropriate integration of these systems to provide the most cost-effective, high-performance result. This initiative would entail the following elements: (1) characterization of the operational needs of the watch supervisor, local controller, and pilots for near-real-time weather information; (2) characterization of the types of weather devices that will or could be available to satisfy the need for near-real-time weather information at airports relative to estimated cost, potential strengths, and potential weaknesses; (3) determination of the appropriate operational role for such devices relative to airport traffic demand and exposure to the various types of weather of concern to runway operations and management; (4) analysis of the appropriate role for each device at those airports that would have two or more in operation; and (5) identification of the key integration issues to be addressed.

The FAA's RE&D program has already yielded significant results in the area of avoiding atmospheric hazards. Deployment of the TDWR system will greatly enhance aviation safety, and future efforts will seek to further minimize these dangers.

Projects which support atmospheric hazards initiatives are:

- 7.1 Next Generation Weather Radar (NEXRAD)
- 7.2 Terminal Doppler Weather Radar (TDWR)
- 7.3 Low-Level Windshear Alert System Enhancements
- 7.4 LLWAS Voice Synthesis
- 7.5 Central Weather Processor (CWP)
- 7.6 Icing Forecasting Improvements
- 9.2 Airborne Windshear Detection and Avoidance

4.3.9 Civil Aviation Security

The FAA is pursuing expanded and accelerated RE&D efforts to enhance the security of airports, aircraft, and the computer systems that control the air traffic system. This civil aviation security program is responsive to the concerns expressed by flight crews, airlines, and passengers. Its objective is to maintain or enhance the level of protection for passengers, aircraft, and airports against existing terrorist threats, while preparing to interdict future threats through the development of new security systems and procedures.

The FAA's aviation security RE&D program is concerned with two principal areas: the physical security of passengers, aircraft, and airport facilities; and the security of ATC computer facilities and systems to ensure the protection and proper management of sensitive air traffic information. Physical security activities have been ongoing for almost 2 decades. Computer security programs are expected to assume increasing importance in view of continuing advances in data-processing technology and the automation of ATC functions.

Physical Security

The FAA has established a program which has been highly successful in preventing aircraft hijackings and other criminal acts against civil aviation. Only one successful U.S. hijacking since 1972 has resulted from the use of a gun that passed through a screening checkpoint, and the agency has been able to identify over 110 hijackings and related crimes that may have been prevented by its security program.

Prototype of Explosives Screening Portal

With the dramatic increase in the volume of passengers and luggage that pass through airports, it is essential that the screening process not unduly impede traffic flow. In 1986, over 1 billion passenger screenings were performed in U.S. airports, almost double the 1982 level. Devices currently in widespread use require only a few seconds for screening to be accomplished.

The FAA's proposed RE&D program for FY 1989 will extend the scope of work already in process, including new systems for detecting explosives in checked and carry-on luggage, in air cargo, and on passengers; enhanced systems for detecting weapons on passengers and in carry-on luggage; an integrated airport security plan for all threat levels; and procedures and devices for identifying and countering threats to aircraft and airport facilities.

Explosives and Weapons Detection

Two basic types of explosives detectors are being developed under the FAA's RE&D program. The first is a "sniffer" which can sense and identify the vapors from explosives. The second, utilizing thermal neutron activation technology, produces electromagnetic energy or nuclear radiation which, by interacting with the explosive in bulk, can sense and identify the substance based on its composition. Preliminary tests have indicated that nationwide use of such devices could prevent explosives from getting on board aircraft in checked baggage or cargo. (Only the "sniffer" is intended for the screening of passengers.) A vapor detection portal to screen travelers will be operationally tested and deployed in a limited number of high-risk airports during FY 1989. Originally developed for aviation security, this technology is now also being utilized by the State Department to enhance diplomatic security.

Other novel approaches to explosives detection will also be explored and, if shown to have sufficient promise, will advance to the prototype development phase. The FAA's civil aviation security research personnel are continually reviewing related technologies for new developments that could have applications in aircraft and airport security. They also frequently evaluate both solicited and unsolicited proposals that offer to develop new technologies or novel approaches.

To the extent that gun manufacturers begin to use composite materials, such as fiber-reinforced plastics and lightweight ceramics, a new security threat emerges. The FAA has in response initiated a program to develop hardware and procedures for detecting weapons made of such materials. If success is achieved, the capability of existing screening systems, which are presently limited to the detection of metallic weapons, will be greatly enhanced.

Airport and Aircraft Security

The nature of the threats to airports and aircraft is changing both in terms of the technology employed and the behavioral profiles of the attackers and their objectives. Studies have been completed to more accurately define the current and future threats to airport security and operations and to assess the vulnerability of U.S. airports to these threats. Current efforts involve the development of security systems and operational procedures for countering the threats in an economically viable, effective manner. Emphasis is placed on security measures for areas where they will be most cost-effective and necessary.

The FAA is also exploring and developing several countermeasures to threats to aircraft and airport facilities. These include development of a passenger/baggage reconciliation system that identifies when passengers have checked baggage but fail to board an aircraft, allowing such baggage to be then removed and examined prior to takeoff; enhancement of the current threat profile through development of a computerized database system containing identifying traits of known hijackers and terrorists; studies on methods for minimizing explosion damage to aircraft in flight; development of enhanced bomb detection for essential components; and design studies of aircraft interiors which minimize locations where weapons, explosives, and contraband can be concealed.

Most of the activities discussed above will draw on the expertise of the aircraft industry, air carriers, and industrial research organizations, under the coordinated direction of the FAA headquarters, the FAA Technical Center, and the Transportation Systems Center. Expected near-term results and associated benefits will contribute to the rapid, reliable screening of increasing numbers of airline passengers and their luggage with improved detection levels and reduced false alarms.

Computer and Telecommunications Security

The importance of minimizing the vulnerability of critical FAA computer and telecommunication systems has been highlighted by major news stories, congressional action (e.g. the Computer Security Act), studies by the General Accounting Office, and internal vulnerability assessments. Penetration of sensitive information systems could cause serious damage resulting in major air traffic delays, with impacts valued at tens of millions of dollars or, in the worst case, midair collisions.

To fulfill its responsibilities under a provision of the Computer Security Act, the FAA is developing formal security plans for existing and future systems, including an approval and accreditation process. The proposed FY 1989 program covers the continuation of work already in progress for evaluating the vulnerabilities of systems operating within the national aviation system and the sensitive software that these systems use to control air traffic.

Expected near-term results and associated benefits include the development of formal security plans and the establishment of a methodology for selecting the most vulnerable system to be protected from unauthorized intrusion in the most cost-effective manner.

Projects which support civil aviation security are:

13.1 Explosives Detection

13.2 Weapons Detection

13.3 Airport Security

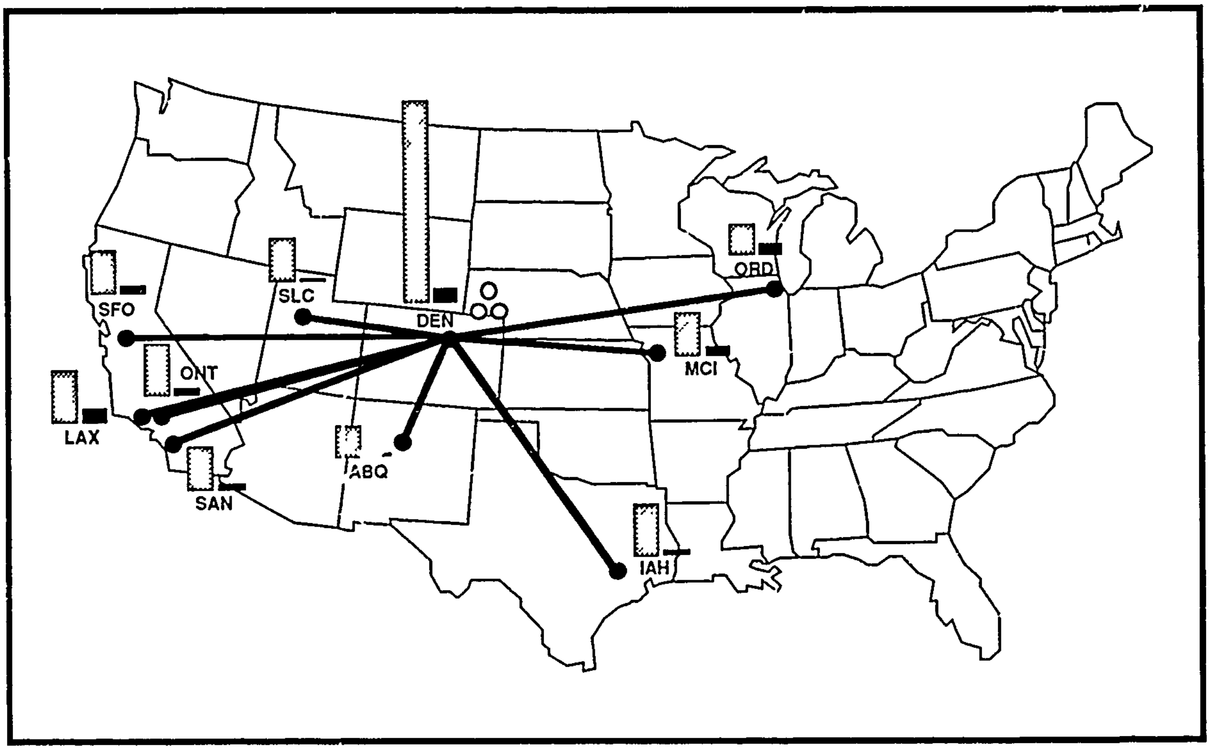
13.4 Security Systems Integration

4.3.10 Operations Research Applications

The U.S. air traffic control system is perhaps the most complex system that humans have devised to date. Given its more than 20,000 operational facilities, 15,000 controllers, and 10,000 maintenance technicians, such a characterization is certainly plausible.

The term "operations research" was coined during World War II, and the scientific origins of the subject date much further back. Over the years, mathematical models for decision analysis have taken hold in business and government. During 1988, the growing role of this function in the conduct of FAA management activities was formally recognized with the establishment of an Operations Research Office.

The new FAA emphasis envisions developing and applying state-of-the-art operations research tools, including computer simulation models and analyses, in support of operational requirements and the FAA's decision-3making process on issues affecting the development, design, management, and operation of the national aviation system. A "marketing" attitude is considered essential to success of the new function. It is to be sensitive to the interests of the aviation community, which includes air carriers, commuter airlines, general aviation, the military, Congress, and agencies of the Executive Branch. Recognizing that it is the concerns of the aviation community that are influencing FAA systems and services, the operations research tools may then be used to evaluate the impacts of proposed changes on system users and operators.



Delay-Reduction Impacts of a "Denver Superport" Predicted by NASPAC Testbed

Both modeling and analyses are planned. Modeling makes use of automated tools to aid the decision maker in selecting the optimal solution. Computer-aided mathematical modeling makes it feasible to solve complex problems that would otherwise take an inordinate amount of time and resources to accomplish. Analysis is seen as the process of formulating and then translating problems into mathematically resolvable descriptions, quantifying and verifying the results of proposed actions, and determining alternative solutions.

First Year Plans for Operations Research

The newly chartered and still formative operations research capability is primarily RE&D-oriented, although its outlook is as broad as that of the entire FAA. Several of the initial tasks have been cited elsewhere in this plan. A summary of the planned accomplishments for FY 1989 is as follows:

- Complete the phase 2 validation of the NASPAC model.
- Develop an initial in-house NASPAC simulation capability.
- Apply the NASPAC model to investigate the impact of the Piedmont hub at the Baltimore-Washington International Airport and the new Denver airport expansion.
- Complete the public release of SIMMOD, an airport and terminal airspace simulation model for use by the FAA and airlines.
- Complete an evaluation and report on a dynamic oceanic track system (DOTS) offering route flexibility and economic advantages.
- Conduct selected studies of operational problems concerning airports and airspace, including benefits analysis and recommendations.
- Upgrade and improve simulation and optimization models for use by both FAA personnel and the aviation community.
- Identify major areas for further application of operations research tools and techniques.

The FAA is committed to increased use of operations research as a basis for management decision making. It is believed that this will enable the agency to make the best use of advancing technology and finite resources, while responding to difficult issues in the balanced best interests of a wide range of aviation users.

Projects which support operations research initiatives are:

2.7 Simulation Model Development and Validation (SIMMOD)

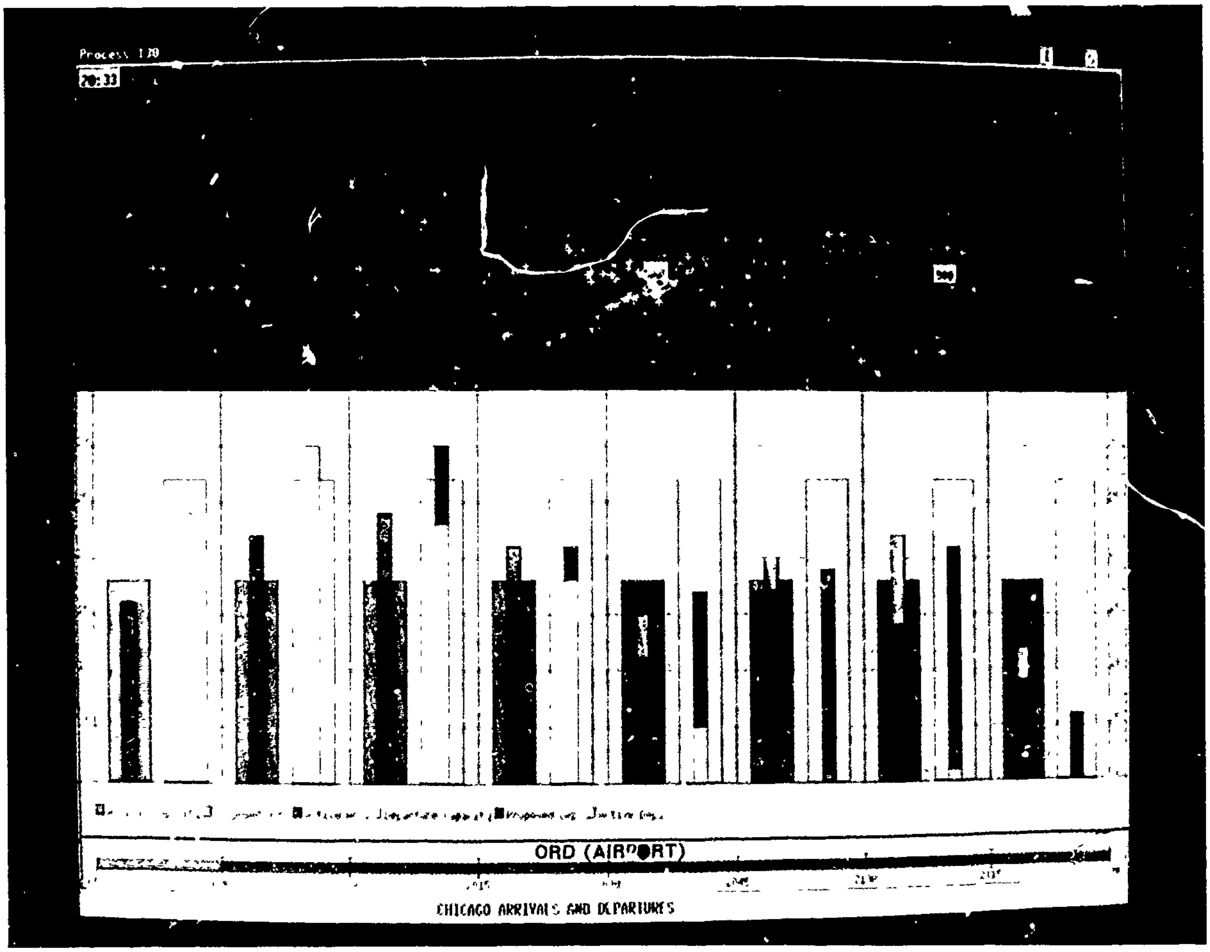
2.8 National Airspace System Performance Analysis Capability (NASPAC)

2.9 Airspace System Models

4.3.11 Airspace Management and Traffic Flow Control

Efficient use of airspace has been a long-standing goal of the entire aviation community. The FAA is committed to providing users with maximum freedom to choose flight paths and schedule flight times. Air traffic managers also seek to efficiently allocate available airspace when the demand for its use exceeds available capacities. This is a special concern as it involves the civil use of airspace normally reserved for military purposes.

The ability to monitor the status of flight operations and accurately predict traffic flows is essential to effective management of airspace. An improved airspace management capability is tremendously important, since it is the key to extracting the maximum benefit from a fixed resource. The recent application of advanced traffic flow control technology at the Los Angeles regional air traffic control center serves as an excellent example. Within a week of the operational installation of the enhanced traffic management system (ETMS) developed by the FAA in conjunction with the DOT Transportation Systems Center, air traffic controllers were able to discontinue routine daily restrictions of traffic into the southwestern United States. The ETMS provided the air traffic management unit with precise traffic predictions based on prevailing conditions, so that restrictions were only imposed for short intervals in order to avoid airspace congestion situations. Traffic flowed more smoothly, airspace utilization was vastly improved, and the extensive controller workload associated with imposing routine daily restrictions was significantly reduced.



Chicago Arrival and Departure Loads Predicted by ATMS Monitor Alert

This is an early indication of how advanced automation capabilities, such as those being implemented through the NAS F&E Plan, are expected to provide long-range user benefits in terms of fuel and time savings. Such savings are anticipated to reach nearly $40 billion. During the next 20 years, the greater accessibility and utilization of real-time flight and airspace information will result in greater accommodation of user-preferred routings, increased availability of military special-use airspace for civil air traffic, and significant reductions in ATC-induced traffic delays.

The RE&D program contains numerous efforts to improve the FAA's ability to more effectively manage the nation's airspace and facilitate traffic flow. The major elements of the program are summarized below. Many of the most important efforts can be broadly categorized as ATC automation activities needed to support improved airspace management and traffic flow control techniques. Two other initiatives are of interest because of particular airspace concerns. One relates to improved management of military special-use airspace, and the other concerns improved operational efficiency for oceanic flights.

ATC Automation

A contract for the acquisition phase of the AAS was recently awarded. This system will provide the computing capacity and expandable software that will serve as the foundation for the devlopment and implementation of highly automated airspace management and traffic flow control strategies. The RE&D program is developing a number of systems and software applications that will enable airspace to be managed more effectively and permit an efficient traffic flow to be achieved. Key elements of the program include AERA, terminal airspace automation, and the ATMS.

A primary objective of AERA is to facilitate the accommodation of user-preferred IFR routes, altitudes, and speeds. It consists of three phases of software that are to provide progressively advanced functions in conjunction with the AAS. The first phase, AERA 1, is in production and will provide the capability for more frequent use of user-preferred trajectories. With AERA 1, controllers will have an automated means of checking for potential conflicts involving separation standards, special-use airspace, and traffic flow restrictions. The second phase, AERA 2, is being readied for implementation and will enable the automated identification and resolution of air traffic conflicts. Major RE&D emphasis is now placed on AERA 3, which will not only fully automate aircraft separation functions but, as with AERA 2, will integrate all traffic management activities. AERA 2 and AERA 3 are to operate in a totally integrated partnership with the ATMS, supported by terminal ATC, departure flow management, and runway configuration management systems. AERA 3 will also be able to take advantage of an aircraft's airborne flight management system capabilities and advanced navigation avionics in order to accommodate preferred flight profiles. The net result of AERA 2 and AERA 3 will be that users will realize more frequent approval of requested trajectories, even in the face of heavy traffic loads.

The terminal airspace automation project was initiated in FY 1988. Its objective is to provide automation aids to controllers that will support improvements in airport capacity by increasing IFR throughputs, reducing controller workload through regularized traffic demand, reducing operational errors, and reducing aircraft delays. The program will provide traffic advisories to accomplish these objectives. One component of the project is a traffic planner and coordinator module that will automatically monitor the flight progress of individual aircraft and compute, based on predicted arrival sequences, possible landing orders given wake-vortex separation requirements and differences in aircraft landing speeds. Another automated tool under development would allow properly equipped aircraft to fly uninterrupted, fuel-efficient, conflict-free, and accurately timed descents from cruise altitude to final approach. Real-time simulation testing of such systems will be initiated in FY 1990, in anticipation of widespread availability of the AAS.

Portions of the ATMS have already been heralded in major newspapers, magazines, and trade publications during the past few years. The ASD provides the ability to monitor, analyze, and control -- via a single display -- the flow of air traffic in real time on a national basis or within any chosen geographic area of interest. The system can predict where traffic congestion will occur hours in advance, allowing controllers to restrict planes from congested areas until there is reasonable assurance that additional aircraft can be accommodated. The ASD has been used in Los Angeles to assist local controllers with the flow of traffic into and out of Los Angeles International Airport, resulting in the ability to accommodate traffic with minimal delay while one of the four main runways was undergoing reconstruction.

More broadly, the ATMS is intended to be used to identify and resolve imbalances between traffic demand and system capacity, up to several hours in advance. ATMS will suggest reroutings, traffic-flow rate adjustments, or ground delays as possible strategies for a traffic management specialist's consideration. The ATMS will also be able to analyze how well air traffic is being handled on a day-to-day basis. Operational traffic indices, such as planned versus actual arrival and departure times and fuel consumption, are to be evaluated with the intent of optimizing desired results through alternate traffic flow control strategies. Direct user access to certain ATMS information is planned, allowing pilots to consider potential traffic congestion, ATC traffic flow restrictions, and special-use airspace restrictions when formulating flight plans.

Special-Use Airspace Management System

A recent General Accounting Office report pointed out that one-fifth of the airspace over the 48 contiguous states has been designated as military special-use airspace. To improve the efficiency and management of special-use airspace, the General Accounting Office made the following recommendations:

- Require standardized user reporting of actual usage data for restricted areas and expand the reporting requirement to other areas, including military operations areas.
- Periodically review usage reports to ensure that the airspace is being used for the designated purpose.
- Establish standards for measuring the effectiveness of special-use airspace utilization to develop a starting point for an all-regional discussion of modification or disestablishment of special-use airspace.

In FY 1989, the RE&D program initiated development of new procedures and an automation strategy for equitably allocating special-use airspace between conflicting civil and military demands. The effort addresses factors currently limiting the FAA's ability to designate and manage this airspace in a manner that is responsive to all users. Specifically, the current interagency coordination procedures are being examined to identify the potential for automation to more rapidly process requests to activate or inactivate military special-use airspace restrictions.

Dynamic Ocean Track System

Past experience indicates that considerable time and fuel savings can be achieved if aircraft are able to fly trajectories that take advantage of prevailing winds and favorable altitudes. In oceanic airspace, flight tracks are rigidly established for the purpose of maintaining safe separations and do not necessarily coincide with the most efficient trajectories.

In 1985, the RE&D program initiated a program focused on oceanic airspace that would enable controllers to generate and manage fuel-efficient flight tracks that respond dynamically to wind, weather, and traffic load conditions. Prototype system requirements will be completed during FY 1988. During FY 1989 and FY 1990, flight tests will be conducted to verify projected fuel burn and time savings for scheduled air carriers. An initial DOTS, capable of automatically determining the most fuel- and- time-efficient tracks for scheduled air traffic over the ocean based on prevailing winds and actual traffic demand, is to be tested through the end of FY 1989 in Pacific airspace. It is to have a capability for recommending, in real time, assignment of individual flights to the most time- and fuel-efficient flight tracks, with due consideration of the route, altitude, and time constraints normally experienced in the ATC system.

Recent RE&D experience has shown the ability to yield real improvements in system capacity and efficiency in short periods of time. It is expected that this pattern will continue in the future. In the longer term, even further advances may be anticipated as RE&D projects provide solutions concerning the four-dimensional control of aircraft movements, including precisely controlled arrivals at destination runways.

Projects which support airspace management and traffic flow control are:

- 2.9 Airspace System Models
- 2.12 Human Performance Research
- 3.1 Advanced Traffic Management System (ATMS)
- 3.2 Dynamic Special-Use Airspace Management
- 3.3 Automated En Route Air Traffic Control 3 (AERA 3)
- 3.4 ATC Applications of Automatic Dependent Surveillance
- 3.5 Terminal ATC Automation (TATCA)
- 3.10 Separation Standards
- 3.13 Fuel Optimization: Dynamic Ocean Track System (DOTS)
- 3.15 Advanced Automation System (AAS)
- 3.16 System Concept Definition

4.3.12 Planning for the Future

Aviation will in a few years reach the century mark, having been the subject of pioneering innovation, investment, competition, and adventure. While the history of innovation would suggest that technology will continue to bring surprises even in a field as mature as aviation, certain trends can be foreseen quite clearly. Views such as the following help form the basis for RE&D by addressing long-range future needs.

Challenges of New Aircraft

Beyond the tiltrotor, the aerospace plane, representative of many new, promising concepts, depends upon the convergence of several high-risk technologies. It is a highly visible and well-funded presidential initiative and a subject of international interest, backed by foreign investments and corresponding development efforts. When and if proven feasible, the aerospace plane will markedly change our transportation options. By that time, changes will be required in ATC facilities and procedures.

Economic and Safety Advances in Conventional Aircraft

An ongoing search for ways to make flying safer and less costly will continue to produce changes in conventional aircraft. Unducted fan engines, newly combining the advantages of turbine and propeller technologies, are soon to be adopted. The use of composite materials for aircraft applications is also expected to grow, due to their favorable strength and weight characteristics. One RE&D challenge will be to develop an understanding of their resistance to failure as the consequence of physical stress or oxidation.

The evolution in electronic design technology that has been under way for the past decades is likely to continue unabated in the foreseeable future. Digital techniques will continue to replace analogue methods, resulting in much greater capabilities at lower costs. Data links, voice communications, and onboard displays of weather and traffic information will all become economic possibilities to an extent far beyond today's achievements. The choice of which capabilities should be permitted or required will continue to be a proper role for government and a subject of FAA RE&D.

Role Changes and ATC Automation

The AAS will modernize ATC facilities and provide the foundation for forms of automation previously beyond reach of system planners. When completed as an RE&D project and implemented with AAS, AERA will offer the first-time realization of automated decision making, with the controller's role advanced from that of a tactician to a manager. Consistent with that advance are possibilities for using automation to increase system capacity.

Research has shown that the capacity of a runway can be increased significantly if arrival times can be controlled more precisely. In today's environment, it is possible to achieve a difference of roughly plus or minus 20 seconds between an arriving aircraft's actual and ideal arrival times at the final fix. For average interarrival times of 150 seconds between aircraft, the reduction of this difference to plus or minus 5 seconds would result in a 20 percent increase in an airport's arrival capacity. As airport capacity limitations become more acute, such increases will be sought, and are likely to become the subject of well-directed RE&D projects.

World Citizen Traveler Perspective

The number of aviation community members will continue to increase, especially those having an interest in international travel issues. Government will have more, not fewer, citizen inputs to which to respond and will need to be increasingly able to address the concerns of large classes of increasingly sophisticated and knowledgeable travelers.

Expanded Uses of Space Technology

The trend of the past 2 decades that has resulted in exploitation of space for aviation and other needs will continue. Access to space via commercial firms has already begun and is likely to predominate over other possibilities.

RE&D Plans for the Future

A fresh approach is being undertaken to formulate a range of advanced concepts and future operating scenarios that will exploit scientific breakthroughs and advanced technologies, as well as respond to important public issues. An integrated vision of the evolution of the national aviation system will be developed based on near-term plans and assessments of improvements that will be required in the mid-term and future. Specific RE&D project categories and planned products are as follows:

System Concept Definition

- National simulation facility
- Synthetic vision

Advanced Concept Studies

- Estimation of future requirements and operating scenarios for the post-2010 time frame
- Assessment of technologies (e.g., artificial intelligence for ATC) applicable to future concepts
- Descriptions of advanced concepts for air traffic services
- Recommendations for new RE&D projects designed to develop promising technologies and concepts
- System analyses that lead to optimal interactions among the parts of the current national aviation system and the post-NAS F&E Plan system

The focus of the advanced concept studies is on the post-2010 time frame, when more advanced vehicles are expected to be operating. The magnitude and nature of the demand for operations may be dramatically different from today's. It may be reasonable to significantly restructure services in response to new requirements and available technologies, especially the dramatic improvements anticipated in computers, expert systems, and sensors. Utilization of the new technologies could result in highly sophisticated automated systems which allow both pilot and controller to manage overall operations while permitting automated systems and advanced sensors to be used to their full capabilities.

Research and development planning will be an integral part of the RE&D program. Included will be analyses in support of the resolution of key issues involving the interests of Congress and others in the aviation community. The product of these analyses will be a coordinated and approved annual plan representative of the decisions and views of FAA management.

Through the foregoing efforts, new directions for RE&D will emerge. In past years, the RE&D program primarily supported the development of facilities and equipment for air traffic control. Future needs will represent a broader mix, with greater balance among human performance, airport, aircraft safety, and long-range issues, in addition to continuing support of ATC system development.

Projects which support future planning are:

2.6 Future System Definition

2.11 Transportation Research Board

2.13 FAA/NASA Cooperative Programs

3.16 System Concept Definition

4.1 Future Communications Requirements and Architecture

5.3 Navigation Systems Development

8.2 Future Satellite C/N/S Systems Applications

14.2 AI Applications to Air Traffic Control

4.4 RE&D Relationship to the NAS F&E Plan

The NAS F&E Plan, developed in 1981, marked an urgent effort for a definitive program for modernizing aging or obsolete ATC facilities. Modern, more cost-effective technologies that will support higher levels of automation in the future became key elements of the plan. The NAS F&E Plan's emphasis has been on accommodating forecasted air traffic growth, without compromising safety, with far greater efficiency in terms of financial and human resources required per aircraft operation. Through the use of ultrareliable and highly automated C/N/S and ATC systems and the physical consolidation of major ATC facilities, the NAS F&E Plan will enable the FAA to handle twice as much traffic with few, if any, additional personnel.

Though to a lesser extent today than in previous years, a number of RE&D activities are planned which directly support the NAS F&E Plan. Table 4-29 depicts the relationship between RE&D projects and associated NAS F&E Plan components.

TABLE 4-29 – RE&D RELATIONSHIP TO THE NAS F&E PLAN

Air Traffic Control Systems
En Route
Advanced Automation System (Project 3.15)
Advanced Traffic Management System (Project 3.1)
Voice Switching and Control System Development (Project 4.3)
ATC Applications of Automatic Dependent Surveillance (Project 3.4)
Flight Service and Weather
Aeronautical Data-Link Communications Applications (Project 4.5)
Central Weather Processor (Project 7.5)
Low-Level Windshear Alert System Enhancements (Project 7.3)
Ground-to-Air Systems
Precision Approach and Landing (Project 5.2)
Aeronautical Data-Link Communications Applications (Project 4.5)
Improvements to Navigation Systems (Project 5.1)
Navigation Systems Development (Project 5.3)
Terminal Doppler Weather Radar (Project 7.2)
Next Generation Weather Radar (Project 7.1)
Radar System Improvements (Project 6.1)
Interfacility Communications Systems
Network Management and Control Equipment (Project 4.2)
Future Communications Requirements and Architecture (Project 4.1)
National Airspace Data Interchange Network II (Project 4.4)

4.5 Opportunities

This plan describes the RE&D program in terms of fixed budgeted activities. However, FAA RE&D is continually evolving. Events since submission of the FY 1989 budget have identified several opportunities which can produce significant near-term benefits. This section presents opportunities which may be initiated in the current fiscal-year program but are not yet funded in FY 1989.

Specific opportunities have been identified as a result of new initiatives which will strengthen the link between RE&D and the FAA's major missions. The programs presented below offer the opportunity to accelerate RE&D in areas that are key to the future of aviation.

4.5.1 Tiltrotor

FY 1989 work in this area would be associated with three principal areas of research: certification, vertiport development, and ATC system requirements. The FAA has set forth an ambitious program that will support the attainment of civil tiltrotor revenue operations by 1996.

4.5.2 Aging Aircraft

Recent events have highlighted the need for an accelerated program to facilitate the understanding and inspection of fatigue, corrosion, and delamination in aging aircraft fuselages and engines. Nondestructive inspection procedures are needed to identify aging aircraft conditions which are hazardous to flight safety, before accidents can occur. FY 1989 funding would enable such efforts to be advanced without delay and would provide the resources needed to address broader concerns regarding the practical or safe lifespan of modern aircraft. It also would accelerate RE&D on the human performance factors related to aircraft design, inspection, and maintenance.

4.5.3 Collision Avoidance

FY 1989 funds would begin a limited installation program for TCAS I earlier than scheduled. Successful implementation would lead to accelerated use of TCAS I by commuter aircraft in accordance with resulting air safety regulations.

4.5.4 Special Surveillance System

FY 1989 funds are being considered for procurement of the radar equipment necessary for assessing the problem of non-transponder-equipped aircraft intrusion into high-density terminal control airspace.

4.5.5 Synthetic Vision

FY 1989 funding would support a technology demonstration program to show the feasibility and practicality of a particular system concept for providing pilots with a visual image during low-visibility approaches. This represents an initiative to transfer DoD and industry technology advancements to a civil aviation application. Such technology offers the prospect of enabling pilots to "see" through rain and fog, an initiative that would use technology to enhance human ability rather than supplant it.

4.5.6 Flight Crew Systems and Operations

A substantial need to increase efforts in the general area of human performance has been identified. Funding for FY 1989 would enable efforts to be advanced across many fronts. Cockpit automation strategies need to be evaluated for use in everyday and emergency situations. Laboratory testing of new man-machine interfaces is needed to develop an improved understanding of the limitations of technologies such as touch panels, voice recognition systems, and "smart" interfaces. Human performance characteristics and limitations on the flight deck need to be identified in order to establish design expectations and reasonable safety certification criteria. The ability of pilots to cope with and effectively manage increasing levels of flight and ATC information needs to be established. Further investigations of causal factors in accidents and incidents are also needed, as are improved flight crew certification standards and training procedures based on an expanded knowledge of human performance limitations.

These opportunities represent an important early step in the FAA's new direction for RE&D. They are indicative of the research and development efforts that will be necessary to ensure the capacity, safety, security, and efficiency of our future aviation system.

Appendix A

RE&D Projects Supporting Cooperative Activities with DoD, NASA, and NWS

Department of Defense

3.2	Dynamic Special-Use Airspace Management
3.16	System Concept Definition (synthetic vision)
5.3	Navigation Systems Development
7.1	Next Generation Weather Radar (NEXRAD)
7.6	Icing Forecasting Improvements
10.8	Environmental Activities
11.1	Aircraft Systems Fire Safety
11.2	Aircraft Crashworthiness/Structural Airworthiness
11.3	Propulsion and Fuel Systems
11.4	Flight Safety/Atmospheric Hazards
11.7	Tiltrotor Certification Support
11.8	Aging Aircraft
12.2	Human Performance Research
14.2	AI Applications to Air Traffic Control
14.9	Interactive Voice Systems

National Aeronautics and Space Administration

2.10	Joint University Air Transportation Technology Program
2.13	FAA/NASA Cooperative Programs
3.5	Terminal ATC Automation (TATCA)
3.11	Wake Vortex Avoidance and Forecasting
5.2	Precision Approach and Landing
8.1	Satellite-Based Air-Ground Communications
9.1	Traffic Alert and Collision Avoidance System (TCAS)

9.2	Airborne Windshear Detection and Avoidance
10.2	Airport Safety (runway surface traction, friction)
10.3	Airport Capacity and Delay (runway design)
10.8	Environmental Activities
11.1	Aircraft Systems Fire Safety
11.2	Aircraft Crashworthiness/Structural Airworthiness
11.3	Propulsion and Fuel Systems
11.4	Flight Safety/Atmospheric Hazards
11.5	Rotorcraft Simulator Standards
11.8	Aging Aircraft
14.3	Causal Factors in Accidents and Incidents
14.4	Human Performance Assessment and Improvement (head-up displays)
14.5	Information Transfer and Management (flight crew information systems)
14.6	Aircraft Automation
14.7	Control and Display Technology
14.8	ATC Weather Information Transfer

National Weather Service and Other Weather Agencies

7.1	Next Generation Weather Radar (NEXRAD)
7.2	Terminal Doppler Weather Radar (TDWR)
7.6	Icing Forecasting Improvements
11.4	Flight Safety/Atmospheric Hazards

Appendix B

Glossary of Acronyms and Abbreviations

A

AAS	advanced automation system
AATMS	advanced air traffic management system
ACF	area control facility
ADS	automatic dependent surveillance
ADSIM	airfield delay simulation model
ADIZ	air defense identification zone
ADM	Advanced Design and Management Control
AEEC	Airlines Electronic Engineering Committee
AERA	automated en route ATC
AFSS	automated flight service station
AI	artificial intelligence
AIAA	American Institute of Aeronautics and Astronautics
ALSIP	Approach Lighting System Improvement Plan
AM	amplitude modulation
AMPS	ATCRBS monopulse processing system
ARSR	air route surveillance radar
ARTCC	air route traffic control center
ARTS	automated radar terminal system
ASD	aircraft situation display
ASDE	airport surface detection equipment
ASOS	automated surface observing system
ASR	airport surveillance radar
ASRS	airport surface radar surveillance/aviation safety reporting system
ASTA	airport surface traffic automation

ATA	airport traffic area
ATACT	Air Traffic AERA Concepts Team
ATC	air traffic control
ATCAC	Air Traffic Control Advisory Committee
ATCBI	air traffic control beacon interrogator
ATCF	air traffic control facility
ATCRBS	air traffic control radar beacon system
ATCS	air traffic control specialist
ATCT	air traffic control tower
AT&T	American Telephone and Telegraph
ATIS	automated terminal information service
ATMS	advanced traffic management system
AWOS	automated weather observing system
AWP	aviation weather processor
AXD	Executive Director for System Development

B

BCAS	beacon collision avoidance system

C

CAMI	Civil Aeromedical Institute
CAS	collision avoidance system
CAT	category
CCD	configuration control decision
CDI	course deviation indicator
CDT	controlled departure time
CEP	Central East Pacific

CFCF	central flow control function
CFWSU	central flow weather service unit
C/N/S	communications, navigation, and surveillance
CONUS	contiguous or conterminous United States
CRM	cockpit resource management
CWP	central weather processor
CWSU	central weather service unit

D

DF	direction finder
DFM	departure flow management
DME	distance measuring equipment
DME/P	precision distance measuring equipment
DoD	U.S. Department of Defense
DOT	U.S. Department of Transportation
DOTS	dynamic ocean track system

E

EMI	electromagnetic interference
EPA	Environmental Protection Agency
ERM	en route metering
ETMS	enhanced traffic management system

F

FAA	Federal Aviation Administration
FANS	Future Air Navigation Systems

F&E	facilities and equipment
FIR	flight information region
FMS	flight management system
FRP	Federal Radionavigation Plan
FSAS	flight service automation system
FSDPS	flight service data processing system
FSS	flight service station

G

GA	general aviation
GAO	General Accounting Office
GIC	GPS integrity channel
GPS	global positioning system

H

HERF	high-energy radio frequency field
HF	high frequency
HST	hypersonic transport

I

ICAO	International Civil Aviation Organization
ICS	independent cooperative surveillance
ICSS	integrated communication switching system
IFCN	interfacility flow control network
IFR	instrument flight rules
ILS	instrument landing system

IMC	instrument meteorological conditions

J

JSPO	Joint System Program Office

L

LIDAR	light detection and ranging
LIP	limited installation program
LLWAS	low-level windshear alert system
LOFF	LORAN C flight following
LOFT	line-oriented flight training
LORAN	long-range navigation

M

MALSR	medium-intensity approach lighting system with runway alignment indicator lights
MCCs	maintenance control centers
MIS	management information system
MIST	microburst and severe thunderstorm
MIT	Massachusetts Institute of Technology
MLS	microwave landing system
MNPS	minimum navigation performance standards
Mode S	discrete addressable secondary radar system with data link
MOPS	minimum operational performance standards
MPS	maintenance processor subsystem
MRU	military radar unit

MSN	message-switching network
MWP	meteorologist weather processor

N

NADIN	national airspace data interchange network
NASA	National Aeronautics and Space Administration
NASPAC	national airspace system performance analysis capability
NAS	National Airspace System
NAT	North Atlantic
NATSPG	North Atlantic special planning group
NDB	nondirectional beacon
NDI	nondestructive inspection
NDT	nondestructive testing
NEXRAD	next generation weather radar
NICS	NAS interfacility communications system
NMC	National Meteorological Center
NMCE	network management and control equipment
NOPAC	North Pacific
NOAA	National Oceanic and Atmospheric Administration
NOSAM	national oil shortage analysis model
NOTAM	notice to airmen
NPIAS	National Plan of Integrated Airport Systems
NPRM	notice of proposed rulemaking
NRC	National Research Council
NSF	National Science Foundation
NTSB	National Transportation Safety Board
NWS	National Weather Service

O

OAM	Office of Aviation Medicine
ODAPS	oceanic display and planning system
OFCM	Office of Federal Coordinator for Meteorological Services and Supporting Research
OMB	Office of Management and Budget
OMEGA	very low frequency, phase comparison radionavigation system operated by the United States and a consortia of other countries
OSI	open systems interconnection
OST	Office of the Secretary of Transportation
OSTP	Office of Science and Technology Policy
OTA	Office of Technology Assessment

P

PIREP	pilot report
PMS	performance management system
PSN	NADIN packet-switching network

R

RCE	radio control equipment
RCL	radio communications link
RCMS	runway configuration management system
RDSIM	runway delay simulation model
RE&D Plan	Research, Engineering, and Development Plan
RF	radio frequency
RFF	rescue and firefighting

RGCSP	review of the general concepts of separation panel
RML	radar microwave link
RMMS	remote maintenance monitoring system
RNAV	area navigation
RNPC	required navigation performance capability
ROT	runway occupancy time
RTCA	Radio Technical Commission for Aeronautics
RVR	runway visual range
RWP	real-time weather processor

S

SAE	Society of Automotive Engineers
SBIR	Small Business Innovation Research
SC	special committee
SIMMOD	simulation model development and validation
SRT	systems requirements team
SSR	secondary surveillance radar
SST	supersonic transport
STEP	Service Test and Evaluation Program
STOL	short takeoff and landing
STORM	stormscale operational and research meteorology
SUA	special-use airspace

T

TACAN	tactical aircraft control and navigation
TATCA	terminal ATC automation
TCA	terminal control area

TCAS	traffic alert and collision avoidance system
TCS	tower communications system
TDWR	terminal Doppler weather radar
TERPS	terminal instrument procedures
TMS	traffic management system
TMU	traffic management unit
TNA	thermal neutron activation
TRACAB	terminal radar approach control in the tower cab
TRACON	terminal radar approach control facility
TRB	Transportation Research Board

U

UHF	ultra-high frequency
UPT	user-preferred trajectory
USAF	U.S. Air Force

V

VFR	visual flight rules
VHF	very high frequency
VIEWS	visual imaging electromagnetic window system
VMC	visual meteorological conditions
VOR	VHF omnidirectional range
VORTAC	VHF omnidirectional range/TACAN
VSCS	voice switching and control system
VTOL	vertical takeoff and landing

W

WAT	West Atlantic
WCP	weather communications processor
WMSCR	weather message switching center replacement

#

2D	2-dimensional
3D	3-dimensional
4D	4-dimensional

Appendix C

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Appendix D

Summary Proceedings
of the Federal Aviation Administration
Research, Engineering, and Development Conference

December 6 and 7, 1988

VOLUME I

Introduction

The Federal Aviation Administration (FAA) is currently engaged in a determined effort to revitalize its Research, Engineering, and Development (RE&D) program. Concurrent with major revisions to its organizational structure, the FAA is developing new RE&D planning and management processes and broadening the content of its program.

During the past decade, air commerce has become dependent on a sophisticated infrastructure of high-technology systems and highly skilled people. The system is developed, operated, and maintained by a complex partnership of private-sector and government enterprises. Because it must operate as a system, growth and improvements are not possible without cooperative planning and a well-designed research and development program.

The Research, Engineering, and Development Conference was held in Washington, D.C., to obtain comments and recommendations from the aviation community for improvement to the FAA RE&D program. Inputs from the conference will be thoroughly evaluated as part of the RE&D planning process. This is an important step in the development of the FAA's program and in strengthening the interaction with the aviation community.

A draft of the 1989 RE&D Plan was furnished to participants and used as a basis for discussion. Approximately 400 members of the aviation community participated, representing a variety of institutions that use, sponsor, or perform aviation research and development.

The conference format consisted of opening remarks from the FAA, Congressman Tom Lewis's discussion on the importance of FAA RE&D, and four sessions of panel discussions organized by major mission areas. Panelists, who represented principal users of the aviation system, had been furnished earlier drafts of the 1989 plan in order to be able to study its contents and prepare a response. FAA panel moderators summarized current project plans and called on panelists for comments and recommendations. Following the panel presentations, the sessions were opened for questions and comments from the floor.

John Turner, Acting Associate Administrator for Advanced Design and Management Control, chaired the conference and introduced Michael Goldfarb, FAA's Chief of Staff. Mr. Goldfarb stated that aviation safety statistics were improving and that we are turning the corner following the air traffic controller strike. This will allow the FAA to now change its focus toward a longer look and view of the future. He made the following points:

- There is a greater emphasis on human factors and a more significant role for RE&D.

- RE&D will have a much greater influence over FAA policies and goals. The recent reorganization is the first "conceptual" reorganization so that the FAA's executive directors work in a coordinated and integrated manner on problems, as shown by the Chicago O'Hare task force.

- We need to move away from technology as a goal and move to technology as a vehicle to achieve goals. We have got to stop holding FAA accountable for simply quantifying benefits, because many cannot be quantified.

- The plan begins to address technologies, such as satellites, that can break the paradigm of a ground-based air traffic control (ATC) system. But we need to have our ATC people work closely with the development efforts and show that automation is not a threat to their jobs. There is also a need to manage airspace, rather than just separate aircraft.

He ended with a request to industry to provide a means of technology transfer to help train and support the FAA work force. He also requested a greater emphasis on industry for the use of independent research and development to join the FAA and support the efforts that will help us go forward in partnership.

Joe Del Balzo, Executive Director for System Development, was the next speaker. He reiterated Administrator McArtor's recognition that an aggressive RE&D program is essential for future growth and expansion of our National Airspace System and his challenge to the FAA to revitalize and refocus the RE&D program. Joe Del Balzo outlined a set of principles against which the FAA will measure its success:

- The RE&D program must focus on specific, agreed-to problems to be solved with a vision for the future.

- This requires commitment and support, not only from the FAA but from OST, OMB, Congress, the users, and industry. The new Aviation Safety Research Act is indicative of that necessary support from Congress.

- The internal capability exists and is complemented by the reorganization that established the executive directors working together on the development and implementation of an RE&D Plan.

- Sufficient funding is required. Although adequate funding has been available in the past, much of this went to support the NAS F&E Plan, which has put in place the infrastructure to support the future. RE&D funding can now be applied to the exploration of new technology.

- A partnership of industry and government is needed. The FAA cannot do it alone; it needs agreements and cooperation with industry.

- We need to modernize the way we do business internal to FAA, including use of new alternatives, accelerated implementation, use of technology demonstrations, and new procurement philosophies.

- We need a vision of the future and a road map to get there. (At this point, Mr. Del Balzo introduced a [illegible] n the future aviation system developed by the FAA Advanced Aviation System Design Team in conjunction with NASA, DoD, DARPA, and industry.)

The luncheon address was given by the Honorable Tom Lewis, U.S. House of Representatives. Congressman Lewis was author of the Aviation Safety Research Act of 1988, which was a major force leading to revitalization of the RE&D program. In his address, the congressman summarized major provisions of the act, including the requirement that 15 percent of agency research funds be directed toward the solution of long-term problems. He cited post-crash fires, aircraft maintenance, and human factors as examples of areas that should be stressed. Congress made it clear in the legislation that the FAA would work in cooperation with NASA, industry, and the academic community. Finally, Congressman Lewis pointed out that the legislation passed unanimously, sending "as strong a message as Congress ever sends" of the need for longer range research.

The purpose of this report is to provide a summary of the highlights of the conference and a preview of considerations that will affect future revisions of the RE&D Plan. Emphasis is placed on items identified as shortcomings or omissions so that they might be addressed during the FY 1989 RE&D process. Each of the items will be evaluated for need and priority. Based on these evaluations, adjustments will be made to the FY 1989 RE&D Plan, plans will be developed for FY 1990, or the project will be deferred.

General Comments

General comments from all sessions are summarized below.

Current Program and Plan

- The attendees, in general, endorsed the RE&D Plan. The new emphasis on operations research and human performance drew favorable comments.
- With few exceptions, participants approved the major mission areas of safety, security, capacity, and efficiency and the RE&D Plan format/content.
- The safety and capacity missions are more important than the efficiency mission. It should be noted, however, that many programs support both the capacity and efficiency missions.
- Several participants felt that the plan could be enhanced by including information on project budget allocations and priorities.
- Many participants recommended better identification of the interfaces and interdependencies of projects.

Planning Process

- Panelists congratulated the FAA on the open format of the conference and thanked the agency for providing users with the opportunity to comment during the RE&D planning process.
- There was a diversity of opinion among participants regarding the proper balance of near-, mid-, and long-term research efforts.
- Panelists expressed an interest in getting an early look at the budget, along with measures of progress on existing projects, and felt that an explicit view of how the RE&D program was developed would facilitate industry comments.
- Industry supports as a highest priority the formation of an advisory committee to provide the user community with a method of inputting user requirements and ideas on future programs.
- The new ADM organization needs to establish a tracking system that will provide measures of progress on RE&D projects against planned milestones.
- The FAA RE&D program needs to develop an operational concept for the post-2010 system and prepare a specification for this system based on the operational concept. This concept should be developed over the next 2 to 3 years.
- Attendees pointed out that many RE&D projects impact more than one mission area and concluded that criteria will be needed to fully evaluate the impact of programmatic changes.
- Several participants cited the need for a mechanism for scrapping unproductive RE&D efforts and projects.

- A number of participants stressed the FAA's need for additional qualified scientists and engineers to conduct the revitalized RE&D program.

- Attendees agreed that succeeding RE&D conference dates should be set for better coordination with the budget cycle.

FAA and User Common Needs

- Panelists urged further development of an overall systems approach to aviation, involving manufacturers, airlines, users, and the government, as a guide to future RE&D planning.

- Conferees stressed that the FAA and aviation community should jointly establish RE&D program priorities. Such a team effort should begin immediately, they feel, if impacts are to be felt by the 21st century.

Aviation Security Panel

The panel was moderated by **Lyle O. Malotky**, FAA Program Manager for Security Research and Development. Participants were the following:

Donnie Blazer, Federal Aviation Administration, Office of Aviation Security

Captain H. Lou Bradley, Air Line Pilots Association

Thomas Browne, Airport Operators Council International

Michael Jacobs, Department of State

Craig Spence, American Association of Airport Executives

Ronald Welding, Air Transport Association of America

William Wall, Federal Aviation Administration, Office of Aviation Security

After brief presentations by panel members, a general discussion was conducted, including comments from the floor.

The panel strongly endorsed the FAA program for aviation security and offered the following observations:

- The greatest security threat is that posed by international terrorist organizations. Bilateral and multilateral efforts will be required to adequately address this problem.
- The incidence of terrorist activities is increasing, particularly against the United States. This threat is also becoming more sophisticated.
- The use of smaller explosives, liquid explosives, composite handguns, and other devices will increase the threat.
- Present security measures are generally effective: last year more than 3000 firearms were detected.
- Each airport is different. Security guidelines are important, but airport-specific programs are also necessary, including steps to ensure that enhanced security does not unnecessarily impede traffic flow.

FAA panel members outlined the program, noting that major emphasis is being placed on the following areas:

- Deployment of thermal neutron activation (TNA) explosive detection systems.
- Completion of vapor detection explosive screening systems for passengers.
- Extension of vapor detection system to checked and carry-on baggage.
- Extension of TNA system to carry-on baggage.

- Development of a detector for nonmetallic handguns.
- Development of an integrated airport security program.

The industry representatives on the panel supported the above programs and agreed that additional resources were needed in the following areas:

- Threat evaluation.
- Airport perimeter security -- multiple sensor integration.
- Airport command/communications systems.
- Airport access-control systems.
- Compact and portable vapor detection systems.
- Explosives vapor detection for checked and carry-on baggage.
- Improved hijack policies and procedures, e.g., "no takeoff" rule.
- Improved hijack communications systems.
- Security guidelines for airport upgrades and new construction.

Other items discussed by the panel and audience included:

- Computer security.
- Strengthened airport baggage lockers.
- Strengthened (least-risk) locations on aircraft for potential disposal of explosives.
- Security measures for unattended aircraft at foreign airports.
- Security design analysis for aircraft -- bomb concealment, bomb risk analysis, and strengthened cargo holds and high-risk areas.
- Passenger screening procedures.

Aviation Efficiency Panel

The panel was moderated by **Neal A. Blake**, FAA Acting Deputy Associate Administrator for Advanced Design and Management Control. Participants were the following:

Steve Brown, Aircraft Owners and Pilots Association

J. Roger Fleming, Air Transport Association of America

Webster Heath, Aerospace Industries Association of America

Captain Jack Howell, Air Line Pilots Association

Irving R. Reese, Boeing Commercial Airplanes

Ronald Swanda, General Aviation Manufacturers Association

John Zugschwert, American Helicopter Society

After brief presentations by panel members, a general discussion was conducted, including comments from the floor. The following major points were made relating to the FAA's efficiency mission as expressed in the RE&D Plan:

- User efficiency should be given consideration, particularly in areas such as airport-to-airport travel time.

- Research is needed to increase the efficiency of pilot and controller training methods. Alternatives to be investigated could include the additional use of simulators, interactive videos, and tests of judgment. A relationship should be established between training methods and future performance.

- RE&D is needed to smooth the transition to the microwave landing system (MLS), especially from the user point of view.

- Mode C functions need to be added quickly to current automated radar terminal system capabilities so that general aviation aircraft equipped with Mode C transponders can be properly detected and tracked at terminal radar approach control facilities.

- The future automated air traffic control system must fully utilize the capabilities of onboard avionics systems. This will include use of airborne traffic displays by the pilot for providing self-separation functions.

- RE&D is needed to make aircraft certification simpler and more efficient and to enable greater delegation to manufacturers (self-certification). Certification efficiency is not just an issue for rotorcraft, as stated in the plan, but also for supersonic transports and new or derivative conventional aircraft. Efficient certification of software changes in avionics is also needed.

- Better use needs to be made of the National Transportation Safety Board accident and safety databases.

- Military technology could profitably be used in commercial aircraft. Examples cited were:
  - Burst communications with the ground and automated message transfers.
  - Helicopters that can land under zero-zero minimum visibility conditions and safely hover at 500 feet and under.
- The wake-vortex program needs to be augmented through the addition of wake-vortex alleviation devices on the aircraft.
- A major effort is needed to define the role of the human in the future automated air traffic control environment.
- The FAA should strongly support development of vertiports, which could be utilized by tiltrotor vehicles to off-load main runways at high-density airports.
- The FAA RE&D program needs to provide the infrastructure to support efficient IFR helicopter operations.
- The RE&D program should support airport technology programs, including improved pavements and greater use of short runways. In addition, the FAA should define the role of subhubs and wayports in the future system.
- For the near term, the FAA should proceed with implementation of LORAN C and GPS services. For the longer term, greater emphasis should be placed on the use of satellites for communications, navigation, and surveillance.
- Low-cost avionics are needed. Users will equip their aircraft if there is a utility advantage. For example, one-third of general aviation aircraft have LORAN C, even though it is not required.

Aviation Safety Panel

The safety panel was moderated by **Keith B. Potts**, FAA Acting Associate Administrator for Aviation Safety. Participants were:

William Hoover, Air Transport Association of America

Frank Jensen, Jr., Helicopter Association of America

John S. Kern, Federal Aviation Administration, Regulation and Certification

E. Richard Meinert, Aerospace Industries Association of America

Siegert B. Poritzky, Airport Operators Council International

Captain Theodore Selken, Air Line Pilots Association

Lane L. Speck, Federal Aviation Administration, Air Traffic Plans and Requirements Service

FAA panel members summarized the agency's safety mission elements and RE&D projects and presented descriptions of the FAA organizations responsible for safety. This was followed by brief talks from each of the industry panel members, with comments and recommendations on the RE&D Plan, process, and program. Questions and comments from the floor and general discussion periods followed each of the presentations.

The following comments were offered on the overall safety program and planning process:

- Users generally agree with the RE&D program for safety. Through a number of task forces and committees, industry associations have contributed to the development of many of these initiatives and will support FAA efforts to obtain funding for the required projects.

- Operators concur with the FAA's proposed emphasis on human performance as the area offering greatest potential payoffs in safety research.

- Industry associations wish to participate in further team efforts to define safety needs, establish priorities, and coordinate RE&D efforts. Industry groups also recognized a need to provide recommended priorities to the FAA. As a corollary, industry needs a better indication of resulting FAA priorities.

- Safety improvements are often included as a part of efficiency- and capacity-enhancing projects. The FAA and aviation community should make sure that the safety mission is not compromised through budget-cutting exercises.

- An effective safety program for helicopters requires accurate data and statistics on which to base priorities. The FAA should work to improve the accuracy of its internal information gathering and make better use of external data.

Although no major changes in the safety program were recommended, conference participants provided recommendations for additional consideration and emphasis in a number of specific areas.

Aspects of aircraft safety RE&D which were recommended for accelerated attention include:

- Crashworthiness testing of commuter and general aviation aircraft -- Design decisions on new models are imminent and test results will be needed shortly. Test vehicles are available.

- Effects of multiple site cracks in aging aircraft -- Technical knowledge is needed before political decisions are made on this issue.

- Development and implementation of crashworthy fuel systems -- Fuel management and containment design improvements from military studies may be applicable to the next generation of civil aircraft.

- Planning for future safety improvements -- Because of increasing lead times for aircraft development and production, the FAA should be planning now for technological improvements in aircraft and avionics that it hopes to see incorporated in the future aviation system.

Recommended additional areas for research relating to weather hazards include:

- An assessment of the effects of lightning-induced electromagnetic interference on flight and engine controls -- With the growing use of electronic controls, this area could become critical.

- Investigation of the potential for airborne windshear prediction capabilities -- An active system with low false-alarm rates is needed by operators.

- Development of airborne ice detection and de-icing systems.

- A means for improving low-visibility taxiing capabilities.

In the human performance area, the FAA was urged to ensure that continued emphasis would be placed on measuring and understanding the effects of automation and fatigue. An additional program to develop training for cockpit resource management was suggested.

Specific comments on air traffic control system safety included the following:

- Efforts should continue on means to reduce the voice communications workload of pilots and controllers.

- Plans for accommodating integration of the tiltrotor into the air traffic control system need to consider nationwide implementation. Plans for helicopter traffic controls have not yet been completely implemented.

- Implementation of the system for monitoring parallel runways should be accelerated.
- The Mode C intruder program is excellent, but is dependent on altitude reporting to be fully effective. The FAA should reassess the risk reduction that could be achieved by requiring altitude-encoding transponders.

- The establishment of a National Airspace System simulation facility for testing of capacity-increasing concepts is essential.

- Terminal area modeling is very important, because it can demonstrate to skeptics the benefits of building new runways.

The following specific comments were made concerning projects that support the capacity mission:

- The terminal air traffic control automation project deserves a high priority -- some participants said the "highest."

- Emphasis on the tiltrotor is important, but the FAA should make certain that other capacity-enhancing efforts are not diminished. (One panelist pointed out the need for heliport planning in addition to that for vertiports.)

The following suggestions were made for additional capacity-related RE&D:

- Research on minimizing the strength of wake vortices generated by aircraft -- One suggestion was that such efforts become an aspect of the aircraft certification process.

- Research on a "cooperative air traffic control environment" in which the pilot is an active participant taking advantage of TCAS capabilities for a cockpit view of surrounding traffic.

- Development of the Mode S data link for communication of information such as clearances in the predeparture phase.

- Development of requirements for equipping reliever airports in order to achieve safety levels similar to those of primary airports.

- Development of better airport lighting guidelines for smaller airports.

- Development of helicopter-specific approaches.

- More attention to noise-related capacity restrictions -- Over 400 airports are now affected, and one participant pointed out a need for better adjudication of this issue with local communities.

- Engineering and development concerned with implementing recommendations of the International Civil Aviation Organization Future Air Navigation Systems Committee, for example, the development of the automatic dependent surveillance system.

Other items discussed by the panel and audience included the following:

- The misuse of mathematical analyses of safety risks -- One panelist felt that this deters the timely implementation of capacity-improvement innovations. It was pointed out, however, that such analyses (e.g., collision risk models) are really used to establish the relative risks of alternative solutions, and that the magnitude of calculated risk is not considered to be an absolute view of reality.

- The microwave landing system -- It was noted that MLS has a major potential for increasing runway capacity and that the program has been an RE&D success, but that implementation of the system has been slow.